SMOLT CONDITION AND TIMING OF ARRIVAL AT LOWER GRANITE RESERVOIR

Annual Report for 1988 Operations

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SMOLT CONDITION AND TIMING OF ARRIVAL AT LOWER GRANITE RESERVOIR

Annual Report
for 1988 Operations

by

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and
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Idaho Department of Fish and Game

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ABSTRACT

This project monitored the daily passage of smolts during the 1988 spring outmigration at two migrant traps; one each on the Snake and Clearwater rivers.

Due to the low runoff year, chinook salmon catch at the Snake River trap was very low. Steelhead trout catch was higher than normal, probably due to trap modifications and because the trap was moved to the east side of the river.

Chinook salmon and steelhead trout catch at the Clearwater River trap was similar to 1987.

Total cumulative recovery of PIT tagged fish at the three dams, with PIT tag detection systems was: 55% for chinook salmon, 73% for hatchery steelhead trout, and 75% for wild steelhead trout.

Travel time through Lower Granite Reservoir for PIT tagged chinook salmon and steelhead trout, marked at the head of the reservoir, was affected by discharge. Statistical analysis showed that as discharge increased from 40 kcfs to 80 kcfs, chinook salmon travel time decreased three fold, and steelhead trout travel time decreased two fold. There was a statistical difference between estimates of travel time through Lower Granite Reservoir for PIT tagged and freeze branded steelhead trout, but not for chinook salmon. These differences may be related to the estimation techniques used for PIT tagged and freeze branded groups, rather than real differences in travel time.

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INTRODUCTION

The Pacific Northwest Electric Power Planning and Conservation Act of 1980 (P.L. 96-501) directed the Northwest Power Planning Council (NWPPC) to develop programs to mitigate for fish and wildlife losses on the Columbia River system resulting from hydroelectric projects. Section 4(h) of the Act explicitly gives the Bonneville Power Administration (BPA) the authority and responsibility to use its resources "to protect, mitigate, and enhance fish and wildlife to the extent affected by the development and operation of any hydroelectric project on the Columbia River system".

Water storage and regulation for hydroelectric generation severely reduces flows necessary for downstream smolt migration. In response to the Fishery Agencies' and Indian Tribes' recommendations for migration flows, the NWPPC Columbia River Basin Fish and Wildlife Program proposed a "Water Budget" for augmenting spring flows.

The NWPPC's Water Budget in the Columbia's Snake River tributary is 1.19 million acre-feet of stored water for use between April 15 and June 15 to enhance the smolt migration but has never been provided in full. To provide information to the Fish Passage Center (FPC) on smolt movement prior to arrival at the lower Snake River reservoirs, the Idaho Department of Fish and Game (IDFG) monitors the daily passage of smolts at the head of Lower Granite Reservoir. This information allows the FPC to optimize the use of the limited Snake River water budget to provide improved passage and migration conditions.

Additionally, the IDFG smolt monitoring project collects data on relative species composition, estimated fish passage index, hatchery steelhead trout vs. wild (natural) steelhead trout ratios, travel time, migration rate, and smolt condition relative to scale loss. By monitoring smolt passage at Lower Granite Dam and at the head of Lower Granite Reservoir, migration rates under riverine and reservoir conditions can be estimated and compared under various environmental conditions. Monitoring sites, on both the Snake and Clearwater arms of Lower Granite Reservoir, permit migration timing of smolts from each drainage to be determined. Also, when possible, relative abundance of hatchery and wild stocks of steelhead trout can be determined. This can be useful information for documenting the rebuilding of wild stocks which is being attempted by other NWPPC projects. Project personnel continually strive to improve smolt trap design and location to assure that the best possible information is provided for water budget management purposes, which will maximize smolt survival.

Smolt monitoring is beneficial for water budget management under all flow conditions, and becomes critical in low flow conditions, when migration rates are slower than during normal or above normal run-off years. In such a year, knowledge of when most smolts have left tributaries and entered areas which can be affected by releases of stored waters allows managers to make the most timely use of the limited water budget resource. Two low flow years (1987 and 1988) have occurred during this smolt monitoring project. The indications are that judicious use of the water budget can greatly enhance the timing and migration rate of juvenile chinook salmon and steelhead trout.

OBJECTIVES

1. Establish timing of the out-migration for the various groups of hatchery-produced and wild chinook salmon and steelhead trout smolts as they leave the Salmon River drainage during low flow years.

2. Establish smolt travel time from the Salmon River index site at White Bird or from release sites to the index sites at the upper end of Lower Granite Reservoir.

3. Correlate travel time with river flows from index sites to Lower Granite Reservoir and Lower Granite Dam.

4. Determine where, when, and to what extent descaling occurs to hatchery reared chinook salmon and steelhead trout smolts released upstream from Lower Granite Dam, and develop management alternatives to reduce scale loss.

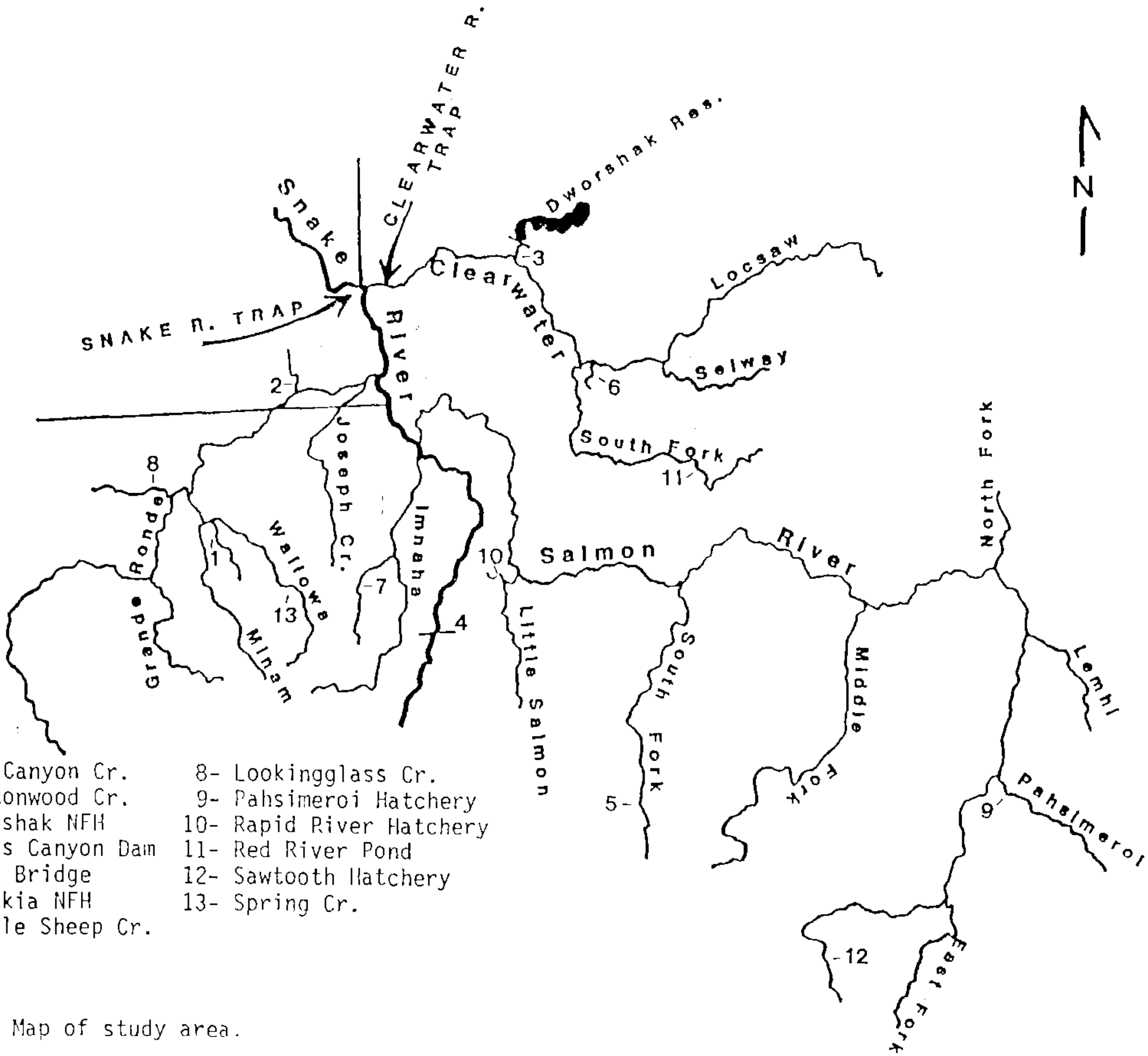
METHODS

Releases of Hatchery-Produced Smolts

Information was obtained from hatcheries which release steelhead trout and chinook salmon juveniles in the Snake River system upstream from Lower Granite Dam. This information included species, number released, date and location of release, and the group identifying freeze brand if used. This allowed us to anticipate the passage of the various release groups and branded fish at downriver trapping sites.

Smolt Monitoring Traps

During the 1988 outmigration, two smolt monitoring traps were employed to monitor the passage of juvenile chinook salmon and steelhead trout. A scoop trap (Raymond and Collins 1974) was stationed on the Clearwater River and a dipper trap (Mason 1966) was located on the Snake River (Fig. 1). Captured smolts were removed daily from the traps for examination, enumeration, and released back to the river. When available, between 150 to 300 chinook salmon and steelhead trout smolts were examined each day for scale loss. Up to 100



1- Big Canyon Cr.
2- Cottonwood Cr.
3- Dworshak NFH
4- Hells Canyon Dam
5- Knox Bridge
6- Kooskia NFH
7- Little Sheep Cr.
8- Lookingglass Cr.
9- Pahsimeroi Hatchery
10- Rapid River Hatchery
11- Red River Pond
12- Sawtooth Hatchery
13- Spring Cr.

Figure 1. Map of study area.

smolts were measured to the nearest millimeter and up to 2,000 fish were examined for hatchery brands, the remaining catch was enumerated by species and released. Smolts handled were anesthetized with Tricaine Methanesulfonate (MS-222). These fish were allowed to recover from the anesthesia before being returned to the river.

To quantify scale loss, each side of a smolt was separated into five areas and each area was examined (Koski et al. 1986). An area was considered "descaled" if 40% or more of the scales were missing. If at least two areas on one side of a fish were descaled, then the fish was considered descaled. Scale loss of this degree is often referred to as "standard" descaling (classical descaling) to distinguish it from other types of descaling. Additionally, beginning in 1985, a fish was also considered to have standard descaling if a band of scales were missing from at least one side of a fish (#9's), and the amount of missing scales was equal to or greater than the loss of 40% or more scales from two areas on a side of a fish as described above. A second classification is "scattered" descaling, which occurred when at least 10% of the scales were missing from at least one side of the fish. Another classification for descaling is "two-area", which exists when the sum of the number of the ten areas on a fish (Fig. 2), which are at least 40% descaled, and the number of sides of a fish which exhibit scattered descaling, equals two or more. The two-area classification includes fish that exhibit standard descaling, as well as fish that would not meet the criteria for the standard category because there was only one descaled area per side. This type of descaling is likely to be as detrimental to fish health as standard descaling.

At each trap, water temperature and turbidity were recorded daily using a centigrade thermometer and 20 cm Secchi disc. The U.S. Weather Service provided daily information on river discharge. The Snake River trap discharge was measured at the USGS Anatone gauge (#13334300). The Clearwater River trap discharge was measured at the USGS Spalding gauge (#13342500).

Salmon River Trap

Due to a lack of funding, the Salmon River trap was not operated in 1988, even though it was a below normal water year. Normally the Salmon River trap is operated only if the February Soil Conservation Service - Snow Survey stream flow forecast at White Bird, Idaho, is less than 90% of the 25-year average. A tentative decision to operate the trap is made in early February using the January stream flow forecast. If the January forecast is below 90% of normal preparation to operate, the Salmon River trap will begin. The final decision is then made using the February forecast, available in early March. Information during near normal to above normal flow years is available at the Salmon River trap for 1983, 1984 and 1985.

TRAP JUVENILE DESCALING FORM (RECORDER____________)

DATE__________ SITE____________ TIME____________ SECCHI DISC______.___M

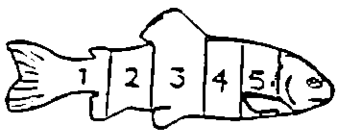
H2O TEMP_____.__C VELOCITY______ TRAP POSITION______________________

Efficiency Tests: Trap down time (hrs)_____________
(# fish marked/released and mark used)
Chinook________________ SH________________ SW________________

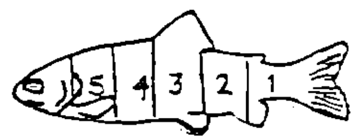
Remarks: ____

DESACALING

RIGHT



LEFT



6. SCATTERED 7. EYE/HEAD INJURIES 8. DEAD 9. DESCALED BAND

	CHIN	STEEL		CHIN	STEEL		CHIN	STEEL		CHIN	STEEL
	descale	brand		descale	brand		descale	brand		descale	brand
1.			1.			1.			1.		
2.			2.			2.			2.		
3.			3.			3.			3.		
4.			4.			4.			4.		
5.			5.			5.			5.		
6.			6.			6.			6.		
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21.			21.			21.			21.		
22.			22.			22.			22.		
23.			23.			23.			23.		
24.			24.			24.			24.		
25.			25.			25.			25.		

FISH SAMPLED: CHINOOK________ HATCHERY STEEL________ WILD STEEL________

Form: TJD-88

Figure 2. Form used to record smolt passage and descaling information. Drawings show the five areas on each side of a smolt which are considered independently for scale loss.

Snake River Trap

The Snake River migrant dipper trap was positioned approximately 40 m downstream from the Interstate Bridge and was attached to bridge piers just west of the draw bridge span by steel cables. This location is near the head of Lower Granite Reservoir, 0.5 km upstream from the confluence of the Snake and Clearwater rivers. River width and depth at this location are approximately 260 m and 12 m, respectively.

A juvenile steelhead radio tagging study was conducted in 1987 (Liscom and Bartlett 1988) which showed that during 1987, 7% of the radio tagged steelhead passed the bridge under the span the trap was attached to, and 30% passed the bridge under the span immediately east of the draw bridge span. Because at least four times more fish were moving under the span of the bridge just east of the draw bridge, the trap was moved to that location on April 27, 1988, after completion of installing an electrical line to the new trap location.

Trap operation in 1988 began March 5 and continued until June 20. There were two interruptions in trap operation due to mechanical breakdown. One for an undetermined amount of time on April 28, and one for four days on May 18 through May 21.

Chinook salmon and steelhead trout smolts were PIT (Passive Integrated Transponder) tagged (Prentice et al. 1987) at the Snake River trap to estimate travel time from the head of Lower Granite Reservoir to Lower Granite Dam. When fish were available, up to 150 chinook salmon, 60 hatchery steelhead trout, and 60 wild steelhead trout were PIT tagged daily. Early in the chinook smolt migration, when Clearwater River trap chinook catch is high and Snake River trap chinook catch is low, chinook are transported from the Clearwater River trap to the Snake River trap, PIT tagged, and released. Individual daily release group travel time was correlated with the abiotic parameters present during the migration period to determine how changes in these parameters affected travel time of smolts through Lower Granite Pool.

Clearwater River Trap

The Clearwater River scoop trap was installed 10 km upstream from the river mouth, 4.5 km upstream from the head of Lower Granite Reservoir. The river channel at this location forms a bend and is 150 to 200 m wide and 4 m to 7 m deep, depending on discharge.

Trap operation began March 8 and continued until June 12 when trap operation was terminated for the season. The trap was down because of excessive debris March 27, and high flow prevented trap operations on April 19 and from May 4 to May 21.

Descaling

Descaling estimates were made on both chinook salmon and steelhead trout at the Snake and Clearwater river trap sites. These values were compared to previous years data to indicate the general condition of the migrating smolts. No descaling information was collected at hatchery facilities in 1988, as had been in previous years. Past data indicates that very little, if any, descaling occurs at the hatcheries or during transport to release sites.

Trap Efficiency

To estimate the number of smolts passing a trap, it is necessary to know what proportion of the migration is being sampled. Additionally, this proportion, which is the trapping efficiency, may change as river discharge changes. To create an equation which describes the relationship between discharge and efficiency, efficiency must be estimated several times through the range of discharge the trap is being operated at. With sufficient information, a regression of efficiency on discharge could then be calculated from the data. With this type of approach an efficiency can then be estimated from any given discharge. The ratio of recaptures to marks released is the estimate of trap efficiency (TE = recaptures/marks released).

Trap efficiency tests were conducted periodically throughout the season on the Clearwater River trap by releasing marked smolts 7 km upriver from the trap site. When trap catch allowed, up to 2,000 chinook salmon were caudal clipped and 2,000 steelhead trout were opercle punched and released upstream. In addition to these fish, six groups of chinook salmon of approximately 2,200 each, and three groups of steelhead trout of approximately 4,000 each, were freeze branded at Dworshak NFH, held there, and transported to the Clearwater River release site and released during the spring smolt migration to estimate trap efficiency. Four groups of freeze branded chinook and three groups of freeze branded steelhead released with the DNFH general release were also used to estimate efficiencies on the Clearwater River trap.

Three hatchery steelhead release groups and three trap caught steelhead groups were used to conduct trap efficiency tests at the Snake River trap. Inadequate numbers of chinook were available in 1988 to conduct efficiency tests on the Snake River trap.

Travel Time and Migration Rates

Migration parameters were calculated on hatchery release groups from release sites to traps sites. Travel time and migration rates through Lower Granite Reservoir were calculated using median arrival times at the Snake and Clearwater River traps, and at Lower Granite Dam for hatchery brand groups and brand groups used for trap efficiency tests. Smolts were PIT tagged at the Snake River trap as an additional method to determine travel time, and daily individual arrival times were calculated at Lower Granite Dam collection facility.

RESULTS AND DISCUSSION

Hatchery Releases

Chinook Salmon

Chinook salmon released into the Snake River drainage above Lower Granite Dam were reared at seven locations in Idaho and one in Oregon. Washington Department of Fisheries made no release of chinook salmon juveniles in the Snake River drainage upstream from Lower Granite Dam that contributed to the 1988 outmigration. A total of 11,176,084 chinook salmon smolts were released at 15 locations in Idaho and Oregon (Table 1).

Sawtooth Hatchery made a fall release of 100,600 spring chinook salmon in the Salmon River in 1987. Dworshak NFH had a fall release of 192,330 spring chinook, and Red River Pond also released 233,100 spring chinook salmon in Clearwater River drainage in the fall of 1987. Lookingglass Hatchery also made a fall release of 164,347 spring chinook salmon juveniles at Lookingglass Creek, Oregon in 1987. All other chinook salmon releases for the 1987 outmigration were made in the spring of 1988 (Table 1).

Steelhead Trout

Steelhead trout were reared at four hatcheries in Idaho, one in Washington, and one in Oregon for release upriver from Lower Granite Dam. A total of 10,798,379 steelhead trout smolts were released at 23 locations in Idaho, eight locations in Oregon, and three locations in Washington (Table 2).

Niagara Springs Hatchery and Hagerman NFH released a total of 748,049 steelhead trout juveniles in the Snake River at Hells Canyon during the fall of 1987. The remainder of steelhead trout releases contributing to the 1988 outmigration occurred in the spring of 1988 (Table 2).

Table 1. Hatchery chinook salmon released into the Snake River system upriver from Lower Granite Dam contributing to the 1988 outmigration.

Release site (hatchery)	Stock	Release date	No. released (no. branded)	Brand
Salmon River				
Sawtooth Hat.	Spring	3/15	1,604,900	
(Sawtooth)		(3/15)	(52,300)	RDT-1
		10/6/87	100,600	
E.F. Salmon R. (Sawtooth)	Spring	3/15-16	249,200	
Yankee F. Sal. R. (Sawtooth)	Spring	3/14-18	725,300	
S.F. Salmon R.	Summer	3/21-24	1,060,400	
(McCall)		(3/23)	(53,900)	RDT-2
Pahsimeroi R. (Pahsimeroi)	Summer	3/15-19	598,500	
Rapid River	Spring	3/15-25	2,630,200	
(Rapid River)		(3/18)	(54,500)	RDT-4
	Drainage Total		**6,969,100**	
Snake River and Non-Idaho Tributaries				
Hells Canyon	Spring	3/22-23	400,600	
(Rapid River)		(3/22)	(53,900)	LDT-4
Lookingglass Cr.	Spring	4/1-5/13	345,943	
(Lookingglass)		(4/1)	(20,128)	LAIM-1
		(4/1)	(19,712)	RAIM-1
		(4/1)	(21,731)	LAIF-3
		(4/1)	(21,659)	RAIF-3
		(5/13)	(21,019)	LAUO-1
		(5/13)	(20,473)	LAUT-1
		9/18-11/3/87	164,347	
		(9/18/87)	(20,030)	RAIF-1
		(9/18/87)	(20,076)	LAIF-1
Catherine Creek (Lookingglass)	Spring	3/31-4/5	151,888	
Big Canyon Creek (Lookingglass)	Spring	3/30-4/8	186,309	

Table 1. (Continued)

Release site (hatchery)	Stock	Release date	No. released (no. branded)	Brand
Imnaha River (Lookingglass)	Spring	3/21-4/21	199,066	
		(3/22)	(20,440)	LAIM-3
		(4/20)	(20,602)	RAIM-3
	Drainage Total		**1,448,153**	
<u>Clearwater River</u>				
Red River Pond (Red River Pond)	Spring	9/28-10/2/87	233,100	
		(9/30)	(46,100)	RDT-3
N.F. Clearwater (Dworshak NFH)	Spring	3/30	1,132,152	
		(3/30)	(20,642)	RA7N-1
		(3/30)	(8,731)	RAR-1
		(3/30)	(22,935)	RA7N-3
		(3/30)	(6,163)	RAR-3
		(3/30)	(60,631)	LAT-2
		3/30	222,737	
		9/28/87	192,330	
		(9/28/87)	(64,425)	LDT-1
		(3/30)	(59,283)	LAH-1
Clearwater R Hwy 95 Boat Launch (Dworshak NFH)	Spring	3/14-4/13	13,173	
		(4/1)	(2,195)	RDK-1
		(4/6)	(2,194)	RDK-2
		(3/21)	(2,197)	RDK-3
		(4/13)	(2,193)	RDK-4
		(3/14)	(2,197)	LDK-1
		(3/17)	(2,197)	LDK-3
White Sands Cr. (Dworshak NFH)	Spring	3/14	200,105	
Clear Creek (Kooskia NFH)	Spring	3/22	778,407	
	Drainage Total		**2,758,831**	
	<u>Grande Total</u>		**11,176,084**	

Table 2. Hatchery steelhead trout released into the Snake River system upriver from Lower Granite Dam contributing to the 1988 outmigration.

Release site (hatchery)	Stock	Release date	No. released (no. branded)	Brand
Salmon River				
Shoup Bridge (Niagara Springs)	A	4/11-12	103,500	
Pahsimeroi River (Niagara Springs)	A	4/8	665,800	
Panther Creek (Niagara Springs)	A	4/12-13	102,800	
E.F. Salmon River (Hagerman NFH)	B	4/6-8	303,564	
Sawtooth Hatchery (Hagerman NFH)	A	4/14-19 (4/15)	1,195,745 (48,745)	LDT-2
Slate Creek (Hagerman NFH)	B	4/25	50,722	
Hazard Creek (Magic Valley)	A	4/12-23	701,300	
N.F. Salmon River (Magic Valley)	A	4/4-10	253,100	
Yankee Fork (Magic Valley)	A	4/4-7	208,000	
Shoup Bridge (Magic Valley)	A	4/6-10	147,500	
Sawtooth Hatchery (Magic Valley)	A	4/6-9	57,700	
Panther Creek (Magic Valley)	A	4/11	162,800	
French Creek (Magic Valley)	A	4/11-14	100,000	
Slate Creek (Magic Valley)	A	4/18-25	346,100	
Hammer Creek (Magic Valley)	A	4/23-25	87,200	
	Drainage Total		**4,485,831**	

Table 2. (Continued)

Release site (hatchery)	Stock	Release date	No. Released (no. branded)	Brand
Snake River and Non-Idaho Tributaries				
Hells Canyon	A	4/23-25	877,400	
(Niagara Springs)		(4/24)	(46,400)	LDT-3
	A	10/19-21/87	404,000	
Hells Canyon	A	10/22-11/5/87	344,049	
(Hagerman NFH)				
Snake R.@ Asotin	B	5/16-23	11,969	
(Dworshak NFH)		(5/16)	(3,996)	LD4-1
		(5/23)	(3,996)	LD4-3
		(5/23)	(3,977)	RD4-1
Little Sheep Cr.	A	4/13-14	246,994	
(Irrigon)		(4/14)	(24,026)	LAIM-2
		(4/14)	(26,023)	LAIF-2
Spring Creek	A	4/16-18	526,877	
(Irrigon)		(4/17)	(25,268)	LAIM-1
		(4/17)	(25,452)	LAIF-1
		(4/17)	(25,131)	LAIM-3
		(4/17)	(25,182)	LAIF-3
		(4/18)	(25,604)	RAIM-3
		(4/18)	(24,980)	RAIF-3
Wildcat Creek	A	4/16-5/2	200,625	
(Irrigon)		(4/20-22)	(49,100)	RAIM-1
		(4/22-26)	(50,555)	RAIF-1
Grande Ronde (R2)	A	4/5-8	199,905	
(Irrigon)				
Catherine Creek	A	4/4-8	62,520	
(Irrigon)				
Wallowa River	A	4/13-19	134,000	
(Irrigon)				
Big Canyon Creek	A	4/13	223,196	
(Irrigon)				
Imnaha River	A	4/21-28	84,503	
(Irrigon)				
Asotin Creek	A	4/20	28,975	
(Lyons Ferry)				

Table 2. (Continued)

Release site (hatchery)	Stock	Release date	No. Released (no. branded)	Brand
Cottonwood Creek (Lyons Ferry)	A	4/15-29	202,676	
Whisky Creek (Lyons Ferry)	A	4/28	50,640	
	Drainage Total		**3,598,329**	
<u>Clearwater River</u>				
Clearwater River (Dworshak NFH)	B	5/3-4	1,432,125	
		(5/3)	(47,601)	RAT-1
		(5/3)	(22,220)	RAT-2
		(5/3)	(14,476)	RAT-3
		(5/4)	(44,446)	RAT-4
S.F. Clearwater R. (Dworshak NFH)	B	4/19-28	165,055	
Newsome Creek (Dworshak NFH)	B	4/20-21	190,708	
American River (Dworshak NFH)	B	4/20-21	56,885	
Clear Creek (Dworshak NFH)	B	4/19-22	254,898	
Crooked River (Dworshak NFH)	B	4/18-19	201,325	
Lolo Creek (Dworshak NFH)	B	4/25-27	200,425	
Eldorado Creek (Dworshak NFH)	B	4/20-22	200,806	
Hwy 95 Bridge (Dworshak NFH)	B	4/13-22	11,992	
		(4/13)	(4,000)	RA4-1
		(4/22)	(3,998)	RA4-3
		(4/22)	(3,994)	RD4-3
	Drainage Total		2,714,219	
	<u>Grande Total</u>		10,798,379	

Smolt Monitoring Traps

Snake River Trap Operation

The Snake River trap was operated from March 5 through June 20, 1988. Trap catch during this period was 3,758 yearling chinook salmon, 2,604 wild steelhead trout, and 16,772 hatchery steelhead trout. A large portion of the chinook salmon (53%) were captured during April while 33% were captured in May (Fig. 3). Twenty-five percent of the hatchery steelhead trout were captured during April, 68% were captured in May, and 7% in June (Fig. 4). Wild steelhead trout passage coincides with hatchery steelhead passage, with 34% of the smolts being captured in April, 64% in May, and 2% in June (Fig. 4).

The Chinook salmon catch at the Snake River trap was very low in 1988 (less than 10% of normal). There appears to be a threshold velocity at the mouth of the trap, below which the trap is relatively ineffective at collecting fish. Chinook catch was affected the greatest because velocities were very low during the majority of the chinook outmigration. An eastern trap location on the Interstate bridge was prepared and the trap was moved to that location on April 27. The majority of the chinook had passed the Snake River trap by the time the trap was relocated so it is not certain whether the new location will provide adequate chinook catches in low flow years.

Snake River discharge, measured at the Anatone gauge, ranged from 21,500 cfs to 30,300 cfs in the month of March (Fig. 4). The average April discharge was 26,000 cfs, with a peak of 40,000 cfs April 22. The average May discharge was 40,300 cfs and the season peak discharge of 52,900 occurred May 25. Flows remained above 40,000 cfs until June 8. After that time flows dropped rapidly to 29,000 by the end of the trapping season on June 20.

Water temperature in the Snake River, at the trap, was between 5° and 7°C during March (Fig. 5). Temperature steadily increased throughout the season. By the end of the trapping season, June 20, water temperature had risen to 19°C.

Secchi disc transparency fluctuated throughout the sampling season (Fig. 5). Influenced mainly by localized rain or thunderstorm events, the secchi transparency shows no obvious correlation to changes in discharge.

Clearwater River Trap Operation

The Clearwater River trap operated from March 8 through June 12. Total trap catch for the season was 63,983 chinook salmon, 9,940 hatchery steelhead trout and 458 wild steelhead trout in 1988. Two peaks of chinook salmon passage were observed at the Clearwater River trap. The first peak began on March 24, prior to the Dworshak NFH release, and was presumed to be from the White Sands Creek, Red River pond, Kooskia NFH release made in Clear Creek and natural production. The second peak was mainly comprised of the Dworshak NFH release

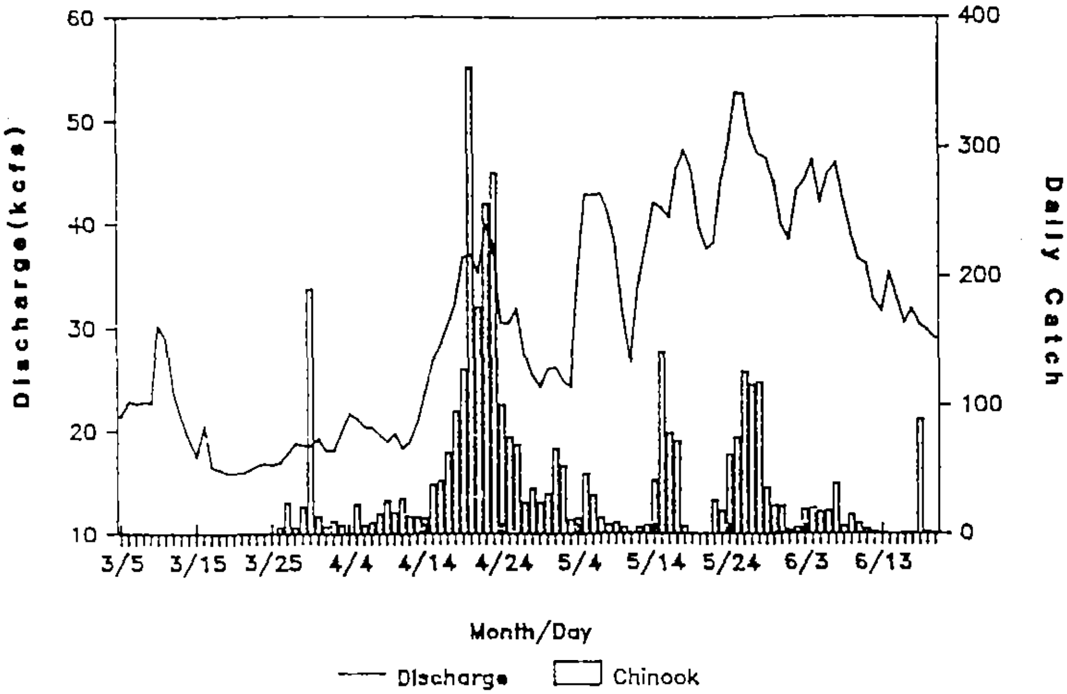
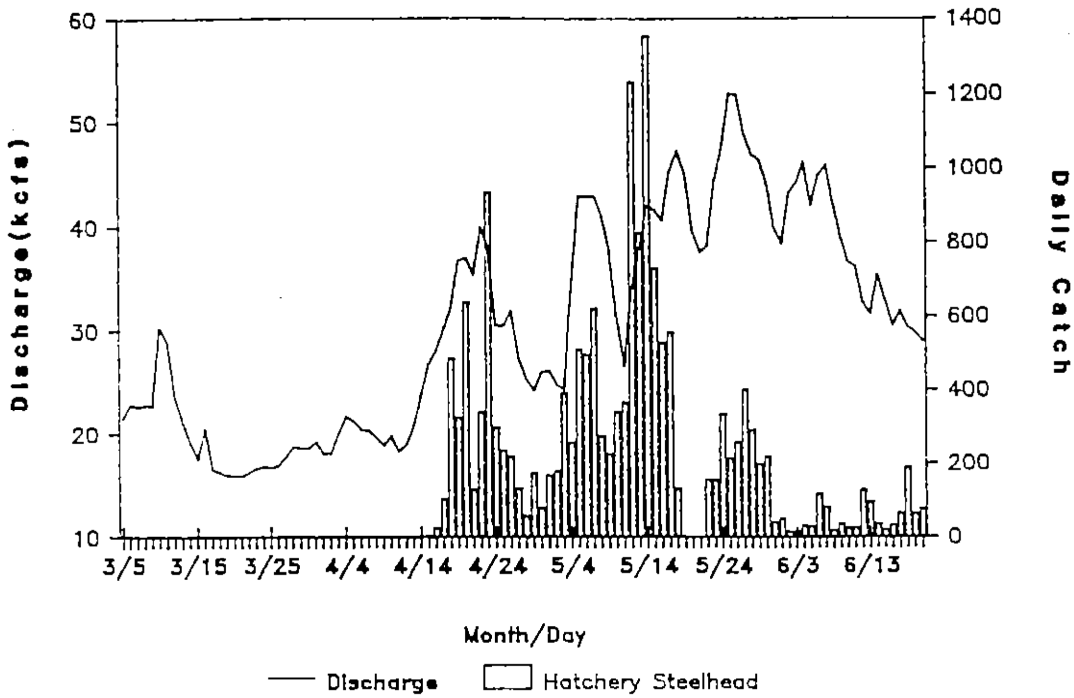


Figure 3. Snake River trap daily catch for yearling chinook salmon overlaid by Snake River discharge, 1988.



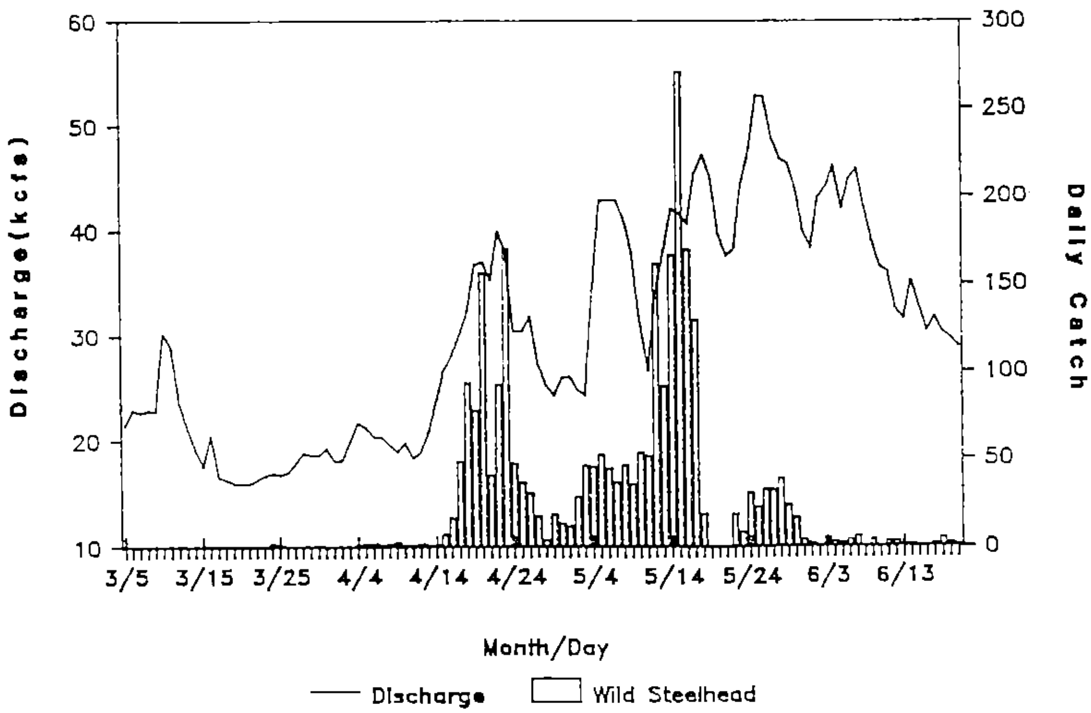
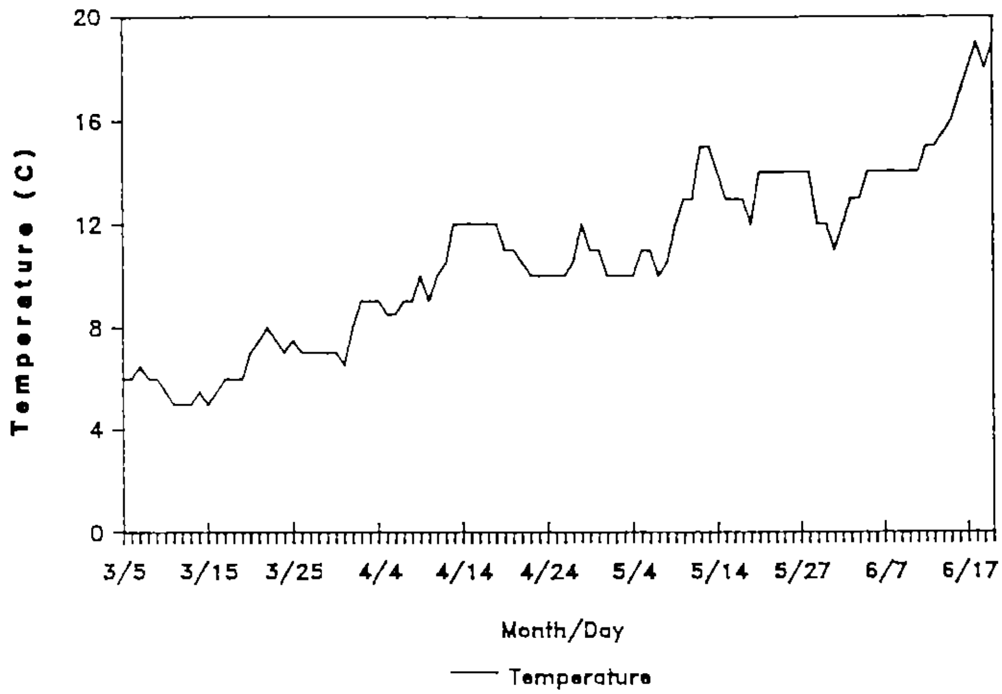


Figure 4. Snake River trap daily catch for hatchery steelhead trout and wild steelhead trout overlaid by Snake River discharge, 1988.



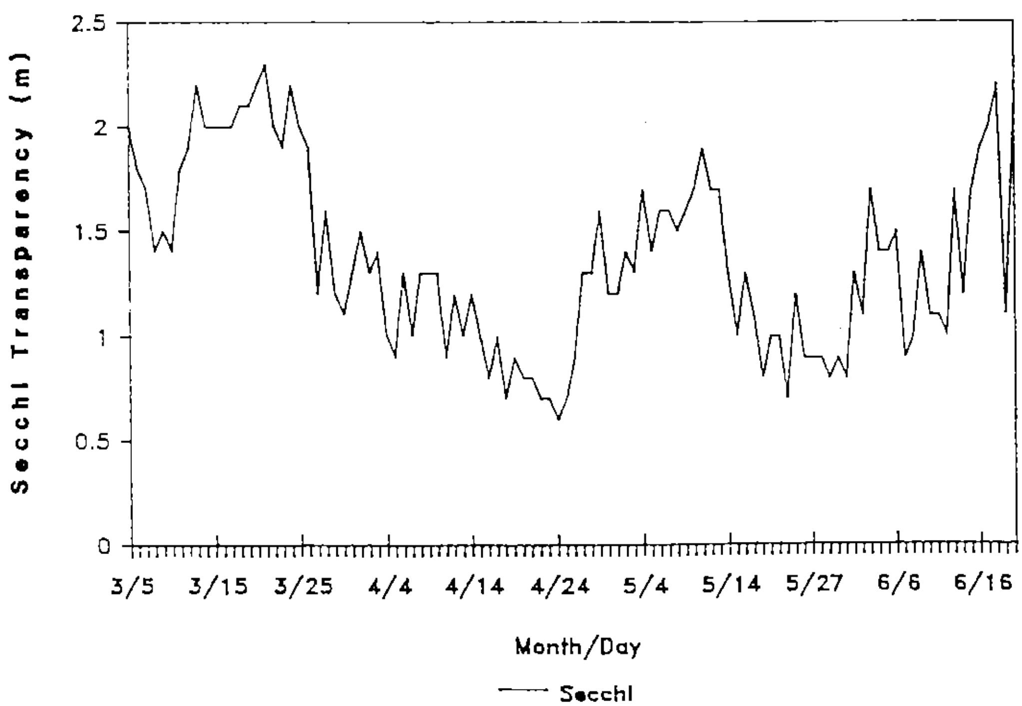


Figure 5. Daily temperature and secchi disk transparency at the Snake River trap, 1988.

made in the North Fork of the Clearwater River (Fig. 6). Dworshak NFH released it's entire chinook production from the hatchery during a 12 hour period, which caused the Clearwater River trap to have a daily catch of 25,929 on March 31, the day after the release.

Daily hatchery steelhead trap catch on the Clearwater River trap peaked on May 3, coinciding with the release of Dworshak NFH steelhead trout smolts from the hatchery and from off-hatchery planting sites (Fig. 7).

Water temperature at the Clearwater River trap was 5.5°C the beginning of the season, March 8, and remained low through April, exceeding 10°C only three times by the end of April (Fig. 8). The high temperature for the season (14.5°C) was recorded the last day of operation, June 12.

Discharge at the beginning of the season was 7,100 cfs and remained below 20,000 cfs until April 15 (Fig. 6). A peak in the hydrograph (maximum discharge for the peak was 35,700 cfs) was seen between April 15 and April 25. Another peak occurred between May 4 and May 10 (maximum discharge for the peak was 43,400 cfs). Discharge remained between 20,000 to 35,000 cfs until the end of the season, June 12. The trap was out of operation during the high discharge from May 6 until May 21.

Secchi disc transparency in the Clearwater River fluctuated throughout the trapping season, and ranged from 0.4 meters to two meters and greater (Fig. 8).

Descaling

Chinook Salmon Descaling

The 1988 standard descaling rate for yearling chinook salmon at the Snake River trap averaged 5.5%. This compares to a previous high of 10.4% in 1987 and a low of 2.5% in 1984 (Table 3).

Standard descaling of yearling chinook salmon observed at the Clearwater River trap in 1988 averaged 0.5%. This value is a five year low and compares to a high of 4.3% in 1987 (Table 3).

Neither the Snake nor Clearwater River trap sample descaling rates were considered detrimentally high. The comparison of this data from year to year can provide an overall picture of general fish health. However, the main function of this data is to access the day to day operation of the traps. An increase in descaling rates during the season may indicate that a problem in the operation of the trap is injuring fish.

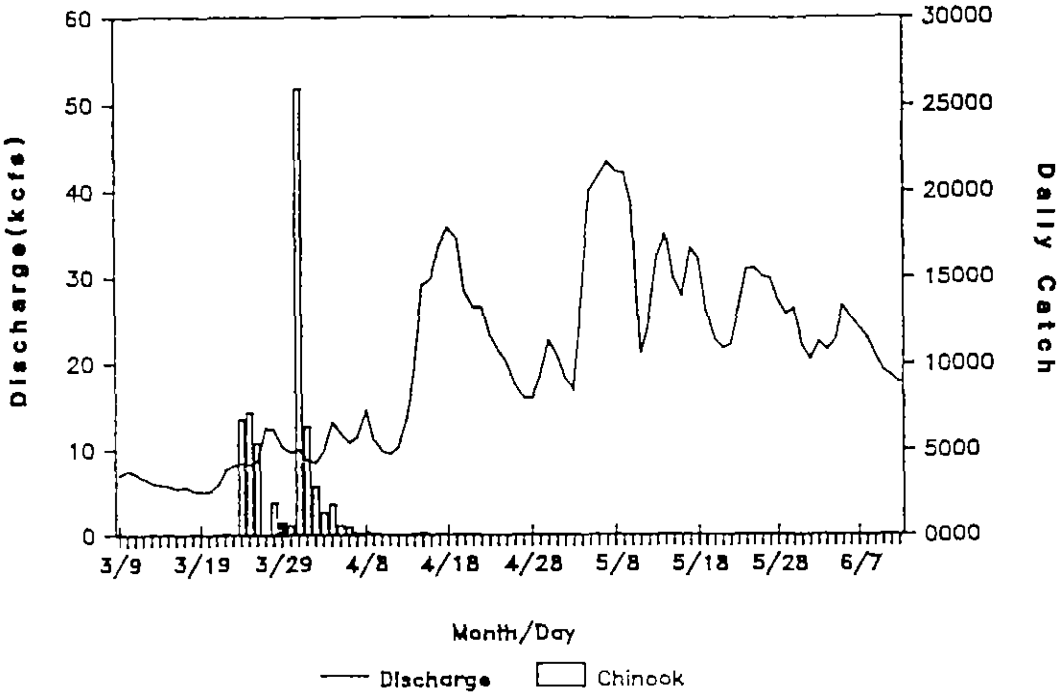


Figure 6. Clearwater River trap daily catch for yearling chinook salmon overlaid by Clearwater River trap discharge, 1988.

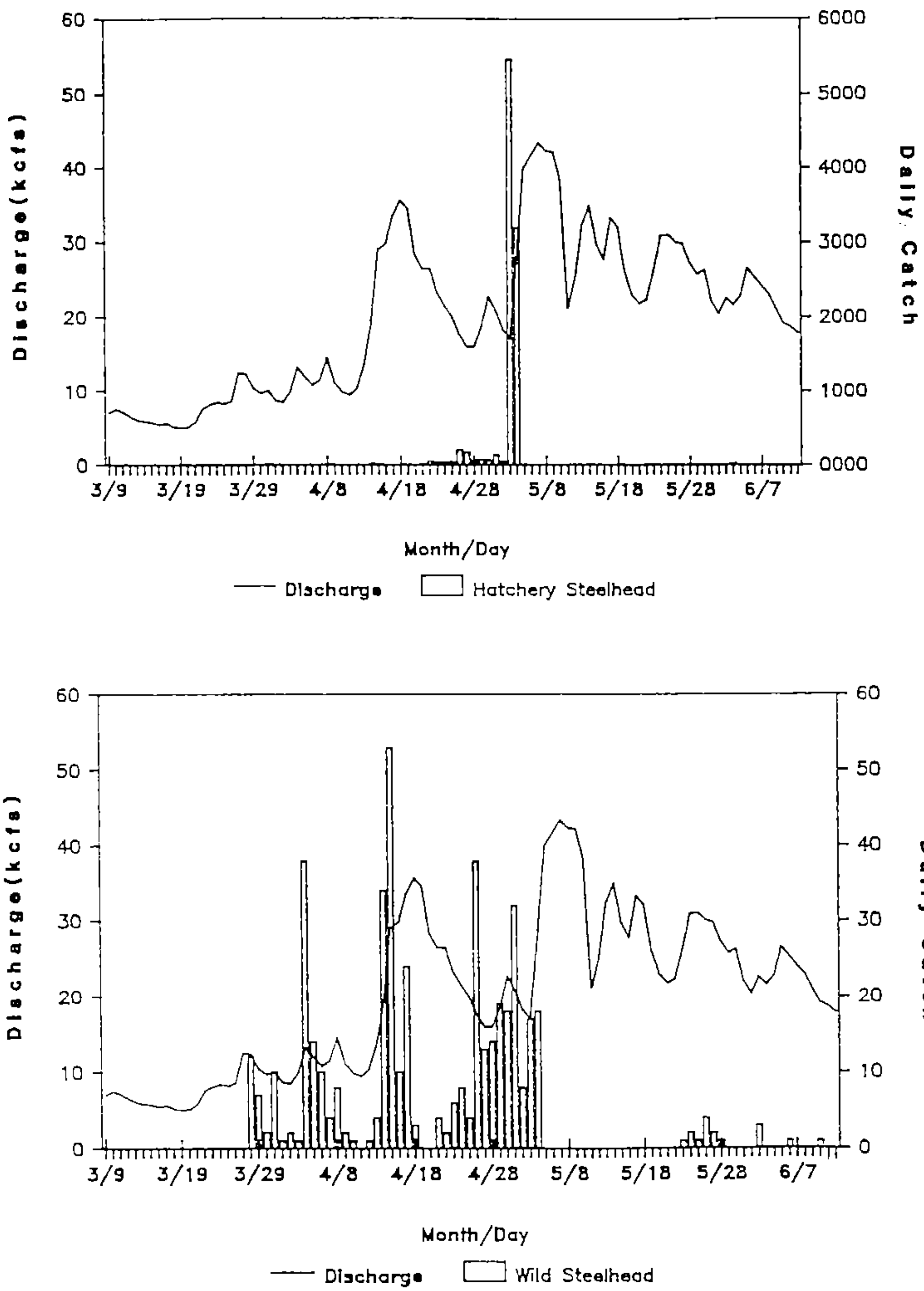
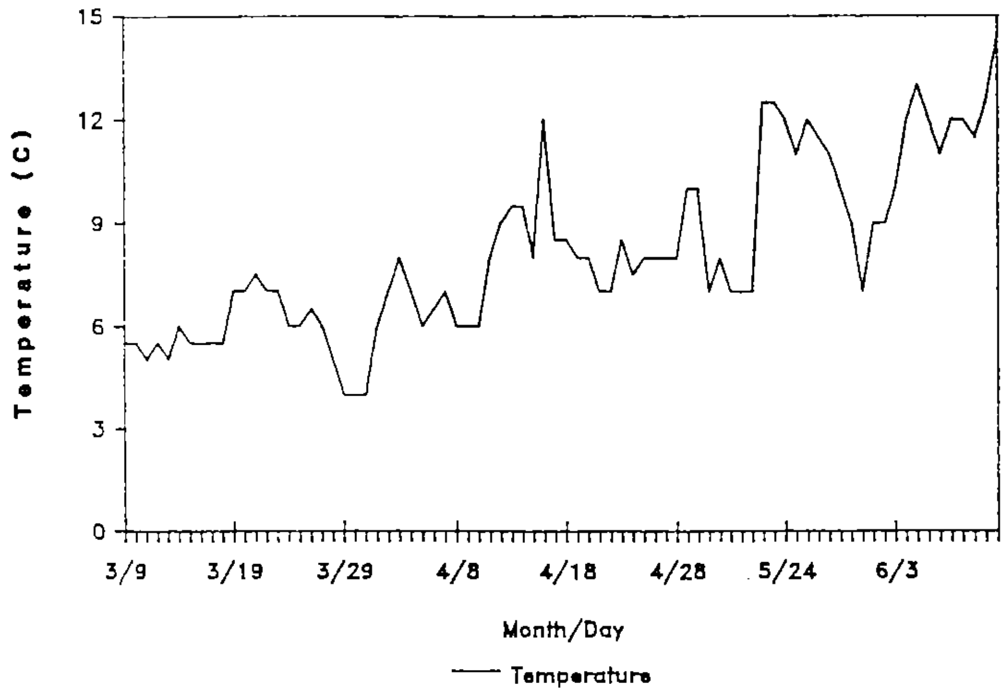


Figure 7. Clearwater River trap daily catch for hatchery steelhead trout and wild steelhead trout overlaid by Clearwater River trap discharge, 1988.



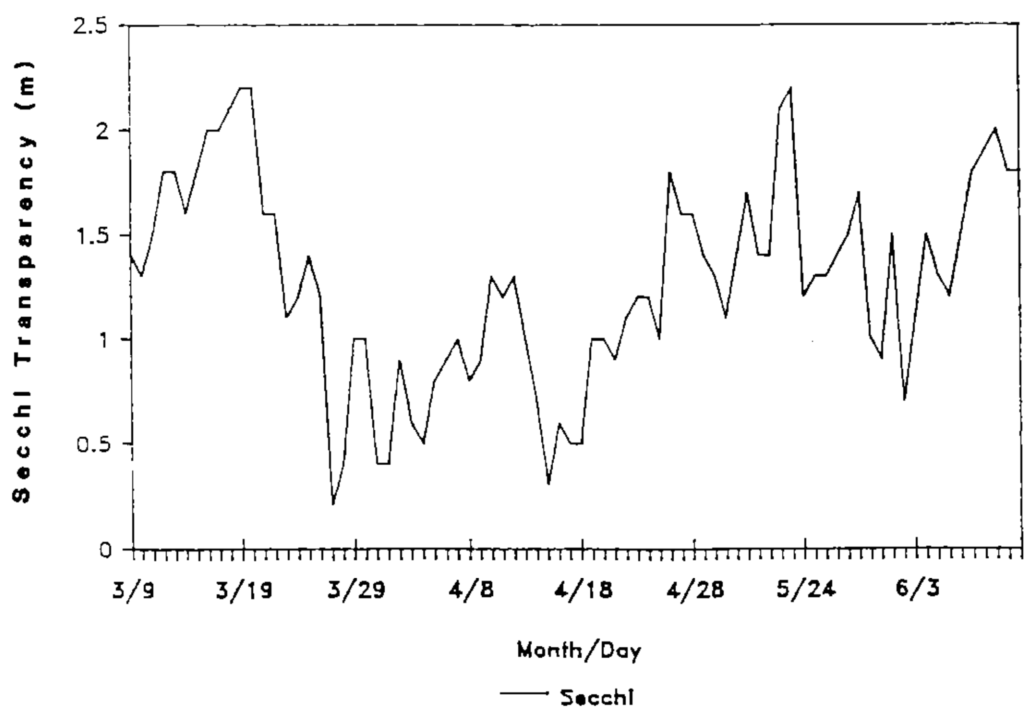


Figure 8. Daily temperature and secchi disk transparency at the Clearwater River trap, 1988.

Table 3. Seasonal mean standard descaling rates (percent) for yearling chinook salmon, hatchery steelhead trout, and wild steelhead trout at the Snake River and Clearwater River traps, 1984 through 1988, and Salmon River trap, 1984 through 1987.

Species	Year	Salmon River	Snake River	Clearwater River
Yearling chinook salmon	1984	4.5	2.5	1.5
	1985	2.4	2.6	0.6
	1986	-	3.8	0.7
	1987	2.0	10.4	4.3
	1988	-	5.5	0.5
Hatchery steelhead trout	1984	8.7	5.5	4.1
	1985	10.1	6.2	2.1
	1986	-	14.5	6.3
	1987	6.2	6.2	4.0
	1988	-	5.9	3.2
Wild steelhead trout	1984	2.1	1.4	0.4
	1985	0.7	0.8	0.7
	1986	-	2.7	0.8
	1987	2.5	3.3	1.3
	1988	-	1.4	1.8

Steelhead Trout Descaling

The 1988 standard descaling rate of hatchery steelhead trout smolts at the Snake River trap averaged 5.5%, whereas wild steelhead trout averaged 1.4%. These values compares to previous highs of 14.7% in 1986 for hatchery steelhead trout, and 3.3% in 1987 for wild steelhead trout. Comparative low descaling rates for the same period were 5.5% in 1984 for hatchery steelhead trout, and 0.8% in 1985 for wild steelhead trout (Table 3). As with the descaling data from chinook salmon smolts, this information can be used to compare the general health of the smolt population from year to year, but it is more appropriately used at this time as an indicator of the day to day trap operation effects on trap caught fish.

Trap Efficiency

Snake River Trap

The daily catch of yearling chinook salmon at the Snake River trap during the 1988 smolt outmigration provided too few fish to conduct trap efficiency tests. With low water conditions, similar to the 1987 season, the velocities at the mouth of the trap throughout the chinook migration were generally less than 1.5 fps. A threshold water velocity of between 1.5 and 2.0 fps at the mouth of the trap is required before the trap will effectively collect chinook smolts. A gross estimate of the 1988 trap efficiency could be comparable to that of 1987 which was 10 to 30 times less than the 1.2% trap efficiency of previous years. The only data available for this estimate is the number of hatchery fish released upstream from the Snake River trap, or potential fish captures, divided by the actual trap catch and comparing this to previous years data.

Trap efficiency for steelhead trout smolts was tested a total of five times during the 1988 smolt outmigration (Table 4). Three of these tests were conducted using trap caught fish, and two tests used hatchery released fish (held at DNFH). One of the tests, using trap caught fish, yeilded a recapture of less than five fish and was not included in any of the analysis. Due to trap efficiencies of less than 20% the data was transformed to arcsin $\sqrt{x}$ values (Zar 1984) in this and subsequent analysis, such that:

$$P' = \tfrac{1}{2}[\arcsin \sqrt{x/n+1} + \arcsin \sqrt{x+1/n+1}].$$

Analyzing the four valid sets of 1988 data shows a trap efficiency, for steelhead trout at the Snake River trap, of 0.65% with confidence limits of:

$$0.0012 \le 0.0065 \le 0.0160.$$

Table 4. Snake River trap efficiency tests for steelhead trout smolts, 1985 through 1988.

	Release date	Recapture/ mark	Efficiency	Discharge (kcfs)
1985	5/4	8/811	0.0099	55
	5/8	1/185	0.0054*	54
	5/18	1/492	0.0020*	50
	5/21	2/314	0.0064*	68
1986	4/24	1/179	0.0056*	80
	4/30	12/874	0.0137	72
	5/21	3/1,345	0.0022*	76
1987	No efficiency tests conducted for steelhead smolts in 1987.			
1988				
trap	4/18	2/866	0.0023*	32
caught	5/13	7/2057	0.0034	38
	5/15	5/1822	0.0027	42
hatchery	5/23	54/3977	0.0136	45
releases	5/23	32/3996	0.0080	45

*Efficiency tests with less than five recaptures were not included in mean trap efficiency estimates.

If the two valid trap efficiency tests from 1985 and 1986 are included in the equation, the resulting trap efficiency equals 0.82% with confidence limits of:

$$0.0038 \le 0.0082 \le 0.0144.$$

Due to several major factors that varried in 1988 and influenced trap efficiency greatly (trap position and river discharge), the combined data from 1985, 1986, and 1988 is considered not to be the most acurate overall trap efficiency estimate. In fact, there is too little data available at this time to accurately estimate any trap efficiency of steelhead trout at the Snake River smolt trap. Also, due to the minimal amount of data avaiable, no further analysis of the data or corrilation of trap efficiency to other parameters was done.

Clearwater River Trap

Since 1984, 33 valid trap efficiency tests for chinook salmon have been conducted on the Clearwater River smolt trap over a wide range of river discharges; 15 of these tests took place during the 1988 sampling season (Table 5). Of these, five test groups were part of the DNFH general release, March 30. Six of the tests were conducted with fish that were marked and held at DNFH until they were transported, via truck, from the hatchery and released at the Highway 95 boat launch. These releases took place at approximately one week intervals during March and April. The remaining four groups consisted of trap caught fish that were marked and transported back upstream for release. These four tests took place during late March and early April.

Trap efficiency can vary under differing flow conditions and from year to year. A one way analysis of variance was used to determine if there was a difference in trap efficiency among years. There were no significant differences among years. Again, due to recapture rates of less than 20%, arcsin $\sqrt{x}$ transformations (Zar 1984) of the data were used in the analysis of the trap efficiencies. Since the data from each year was collected under a variety of discharge conditions, an analysis of covariance was run to see if trap efficiency differed from year to year when adjusted for discharge.

First the underlying assumption of equality of slopes was tested. The hypothesis of equality of the trap efficiency-discharge slopes among years could not be rejected. The subsequent analysis of covariance showed no significant differences due to year when the trap efficiencies were adjusted for discharge. This is basically a test of whether the regression lines relating discharge and trap efficiency for each year have a common intercept, or whether one regression line is higher than another. The data shows no statistically discernable differences for trap efficiencies among years even after adjusting for discharge.

Table 5. Clearwater River trap efficiency tests for chinook salmon smolts, 1984 through 1988.

	Release date	Recaptures/ Mark	Efficiency	Discharge (kcfs)
1984	4/5	4/418	0.0096*	21
	4/21	13/806	0.0161	33
	4/25	3/489	0.0061*	31
	5/10	14/453	0.0309	24
1985	3/25	14/607	0.0230	9
	3/30	45/1,511	0.0298	9
	4/5	6/1,079	0.0056	18
	4/9	2/940	0.0021*	15
	4/16	7/929	0.0075	33
1986	3/27	9/1,555	0.0058	22
	4/2	8/1,714	0.0047	29
1987				
DNFH releases	3/20	43/2,160	0.0199	13
	4/22	50/2,000	0.0250	6
	4/7	165/1,945	0.0848	10
	4/13	74/2,000	0.0370	13
	4/20&28	103/4,000	0.0258	18
trap caught	4/2	33/1,926	0.0171	6
	4/3	11/1,458	0.0075	8
	4/6	15/1,872	0.0080	9
	4/7	15/1,163	0.0129	10
	4/9	9/450	0.0200	12
1988				
Hwy 95 boat launch	3/14	51/2,197	0.0232	6
	3/17	93/2,197	0.0423	6
	3/21	83/2,197	0.0378	6
	4/1	27/2,195	0.0123	9
	4/6	18/2,194	0.0082	11
	4/13	31/2,193	0.0141	14
DNFH release	3/30	1711/60,631	0.0282	10
	3/30	252/8,731	0.0289	10
	3/30	181/6,163	0.0294	10
	3/30	788/20,642	0.0382	10
	3/30	573/22,935	0.0250	10
trap caught	3/24	17/2086	0.0081	9
	3/28	27/1695	0.0159	12
	4/1	16/1631	0.0098	9
	4/2	38/2257	0.0168	8

*Efficiency tests with less than five recaptures were not included in mean trap efficiency estimates.

The data was then pooled over years and a single regression line was fit between discharge and trap efficiency. This relationship was statistically significant (F=6.103, P=0.019), but the R^2 was only 0.152 indicating no interpretable biological meaning can be ascribed to the relationship.

At this point, year and discharge were discounted as significant factors in explaining trap efficiency of chinook salmon at the Clearwater River trap and the average trap efficiency over the 33 tests was calculated along with its 95% confidence limits:

$$0.0155 \le 0.0200 \le 0.0250.$$

Additional data may help to clarify the variables affecting trap efficiency for chinook salmon at the Clearwater River trap.

Steelhead trout trap efficiency at the Clearwater River trap was successfully tested three times during the 1988 season. The estimated efficiency ranged from 0.20% to 0.73%. This data was added to four valid trap efficiency tests that were conducted in 1986 and 1987 (Table 6). When subjected to the same progressive statistical analysis as the chinook data collected on the Clearwater River trap, the steelhead data failed to meet the criteria for pooling of the four years of data. The slopes were homogeneous, but the intercepts were significantly different (F=3.981, P=0.000). This outcome differed from the 1987 analysis of the data in that there was no difference shown at this point at the 0.05 level; but one did exist at the 0.10 level (1987; P=0.071, F=3.761). A significant difference did occur in 1987 when river discharge was added to the equation. It is difficult to determine if indeed the difference occurs between years or between levels of river discharges. This discrepancy should be clarified with the addition of more data in future years.

The 1988 arcsin $\sqrt{x}$ transformed (Zar 1984) trap efficiency data was analyzed by itself, due to the significance of the yearly variation, to derive an average trap efficiency of 0.43% with confidence limits of:

$$0.0003 \le 0.0043 \le 0.0132.$$

Travel Time and Migration Rates

Release Sites to Salmon River Trap

The Salmon River trap was not operated in 1988 due to lack of funding.

Table 6 Clearwater River trap efficiency for steelhead trout smolts, 1985 through 1988.

	Release date	Recaptures/ Mark	Efficiency	Discharge (kcfs)
1985	5/7	2/464	0.0043*	29
	5/11	1/384	0.0026*	33
1986	4/14	7/4,140	0.0017	20
	4/30	1/4,190	0.0002*	20
	5/7	2/4,260	0.0005*	29
	5/11	5/4,247	0.0012	29
1987				
DNFH releases	4/13	6/4,071	0.0015	13
	4/20	9/4,060	0.0022	16
	4/28	2/4,000	0.0005*	26
trap caught	4/21-22	6/1,604	0.0037	13
	4/24	2/775	0.0026*	15
1988				
DNFH releases	4/13	29/4,000	0.0073	14
	4/22	8/3,998	0.0020	27
	4/28	16/3,994	0.0040	16

*Efficiency tests with less than five recaptures were not included in mean trap efficiency estimates.

Release Site to Snake River Trap

<u>Chinook salmon.</u> Due to extreme low discharge during the 1988 juvenile migration, Snake River trap efficiency was very low and the number of branded chinook collected was much smaller than in previous years. As a result, travel time and migration rates could only be calculated between release points and the Snake River trap for two chinook brand groups. Distances from release point to recovery location are represented in Table 7. These fish were released from the Lookingglass Hatchery late in the season when the trap had been moved to the east side of the river and discharge was greater than 40,000 cfs. These two groups were 0-age spring chinook released on May 15. Median travel time to the Snake River trap was three days for one group and four days for the other. Migration statistics for 1984 through 1988 are presented in Table 8.

<u>Steelhead trout.</u> In 1988 a large portion of the steelhead migration occurred after the Snake River trap was moved to the east side of the river and when river discharge was greater than 30,000 cfs. There were 12 groups of freeze branded steelhead trout released above the Snake River trap. Recaptures were high enough for ten of the groups to provide travel time information to the Snake River trap.

The migration rate for the Hells Canyon freeze brand group was four times faster in 1988 (12.3 km/day) than in 1987 (3.1 km/day), but the group was released 29 days earlier in 1987 which probably accounts for most of the difference. The migration rate was considerably slower (5 to 7 times) in 1988 than in years when flows were higher, such as 1985 and 1986 (Table 9).

The Sawtooth group migrated at 29.1 km/day during the 1988 spring migration. A comparison with the 1987 migration rate can't be made because not enough marked steelhead were captured from the Sawtooth group. The migration rate in 1988 was considerably faster than in 1986 (16.6 km/day), although the flow conditions in 1986 were considerably better in both the upper and lower Salmon River. The 1988 migration rate was similar to the 1985 rate (24.9 km/day), and flow conditions were similar both years.

Six of the ten brand groups recaptured at the Snake River trap were released from Spring Creek, a tributary of the Wallowa River. Migration rates for the six groups ranged from 26.9 to 34.6 km/day and averaged 31.3 km/day. Not enough fish were captured at the Snake River trap in 1987 to estimate migration rate for the Spring Creek release site. Migration rate in 1986 was 9.3 km/day and 23.1 km/day in 1985. Flows and release dates varied considerably between these years so it's difficult to compare migration rates between years for this release location.

Two groups of branded steelhead were released from Wildcat Creek, a tributary of the Grande Ronde River. Both groups migrated at 33.2 km/day. This was the first year marked fish were released from this site.

Table 7. River mile & kilometer index for the Snake River Drainage.

	Mouth of Columbia R.		Mouth of Snake River		Lower Granite Dam		Snake River Trap Site		Clearwater R. Trap Site		Salmon River Trap Site	
	mi	km	mi	km	mi	km	mi	km	mi	km	mi	km
Mouth of Snake River	324.3	521.8	0.0	0.0	107.5	172.9	139.6	224.6	145.7	234.5	241.4	388.4
Lower Granite Dam	431.8	694.8	107.5	173.0	0.0	0.0	32.1	51.6	38.3	61.5	133.9	215.4
Clearwater R. Trap Site	470.0	756.2	145.7	234.4	38.2	61.5	-	-	0.0	0.0	-	-
Highway 95 Boat Launch	473.2	761.4	148.9	239.6	41.5	66.8	-	-	3.2	5.1	-	-
Dworshak NFH	504.2	811.3	179.9	289.5	72.4	116.5	-	-	34.2	55.0	-	-
Kooskia NFH	541.6	871.4	217.3	349.6	109.8	176.7	-	-	71.5	115.0	-	-
Crooked River	604.3	972.3	280.0	450.5	172.5	277.6	-	-	134.3	216.0	-	-
Red River Rearing Pond	618.0	994.4	293.7	472.6	186.2	299.6	-	-	148.0	238.1	-	-
Snake River Trap Site	463.9	746.4	139.6	224.6	32.1	51.6	0.0	0.0	-	-	101.8	163.8
Asotin Creek	469.6	755.6	145.3	233.8	37.8	60.8	5.7	9.2	-	-	-	-
Mouth of Grande Ronde R.	493.0	793.2	168.7	271.4	61.2	98.5	29.1	46.8	-	-	-	-
Cottonwood Creek	521.7	839.4	197.4	317.6	89.9	144.6	57.8	93.0	-	-	-	-
Lookingglass Creek	580.4	933.9	256.1	412.1	148.6	239.1	116.5	187.4	-	-	-	-
Big Canyon Creek	585.9	942.7	261.6	420.9	154.1	247.9	122.0	196.3	-	-	-	-
Spring Creek	614.4	988.6	290.1	466.8	182.6	293.8	150.5	242.2	-	-	-	-
Catherine Creek	636.9	1024.8	312.6	503.0	205.1	330.0	173.0	278.4	-	-	-	-
Mouth of Salmon River	512.5	824.6	188.2	302.8	80.7	129.8	48.6	78.2	-	-	53.2	85.6
Imnaha River	516.0	830.3	191.7	309.1	84.2	135.7	52.1	83.8	-	-	-	-
Little Sheep Creek	553.8	891.1	229.5	369.3	122.0	196.3	89.9	144.6	-	-	-	-
Imnaha Coll. Facility	565.6	910.2	241.3	388.3	133.8	215.4	101.7	163.6	-	-	-	-
Hells Canyon Dam	571.3	919.2	247.0	397.4	139.5	224.5	107.4	172.8	-	-	-	-
Salmon River Trap Site	565.7	910.2	241.4	388.4	133.9	215.4	101.8	163.8	-	-	0.0	0.0
Rapid River Hatchery	605.8	974.7	281.5	452.9	174.0	280.0	141.9	228.3	-	-	40.1	64.5
Hazard Creek	618.7	995.5	294.4	473.7	186.9	300.7	154.8	249.1	-	-	53.0	85.3
S.F. Salmon @Knox Bridge	719.7	1158.0	395.4	636.2	287.9	463.2	255.8	411.6	-	-	154.0	247.8
Pahsimeroi Hatchery	817.5	1315.4	493.2	793.6	385.7	620.6	353.6	568.9	-	-	251.8	405.1
E.F. Salmon @ Trap Site	873.6	1405.6	549.3	883.8	441.8	710.9	409.7	659.2	-	-	307.9	495.4
Sawtooth Hatchery	896.7	1444.2	573.3	922.4	465.8	749.5	433.7	697.8	-	-	331.9	534.0

Table 8. Migration statistics for freeze branded chinook smolts from release sites to the Snake River trap, 1984 through 1988.

Release site	Year	Median release date	Median passage date	Number captured	Travel time (days)	Migration rate (km/day)	Mean Q (kcfs) Salmon R.	Mean Q (kcfs) Snake R.
Rapid River	1988	1/						
	1987	1/						
	1986	3/27	4/10	237	14	16.3	15.4	82.9
	1985	4/2	4/12	320	10	22.8	10.6	67.6
	1984	4/1	4/18	197	17	13.4	10.1	79.3
Hells Canyon	1988	1/						
	1987	1/						
	1986	3/26	4/3	269	8	21.6	-	83.8
	1985	3/19	4/3	544	14	12.4	-	43.0
	1984	3/20	3/29	704	9	19.2	-	81.4
S.F. Salmon River	1988	1/						
	1987	1/						
	1986	3/28	4/23	229	26	15.8	16.5	78.6
	1985	4/2	4/17	76	15	27.1	14.0	71.0
	1984	4/10	4/24	238	14	29.0	14.5	91.7
Sawtooth Hatchery	1988	1/						
	1987	1/						
	1986	3/17	4/14	49	28	24.9	13.6	81.4
	1985	3/27	4/14	165	18	38.7	9.6	60.1
	1984	3/28	4/21	136	24	29.0	11.8	84.0
Lookingglass Cr.	1988	5/13	5/15	28	3	62.5	-	40.6
	1988	5/13	5/16	24	4	46.9	-	40.6
	1987	1/						
	1986	4/2	4/5	114	3	62.3	-	82.1
	1985	No marked release group.						
	1984	No marked release group.						

1/ Not enough recaptures at the Snake River trap.

Table 9. Migration statistics for freeze branded steelhead trout smolts from release sites to the Snake River trap, 1984 through 1988.

Release site	Year	Median release date	Median passage date	Number captured	Travel time (days)	Migration rate (km/day)	Mean Q (kcfs) Salmon R.	Mean Q (kcfs) Snake R.
Sawtooth Hatchery	1988	4/15	5/8	17	24	29.1	15.1	32.7
	1987	4/14	-	5	-	Not enough recaptures at the Snake R. trap.		
	1986	4/9	5/21	11	42	16.6	24.0	73.4
	1985	4/9	5/7	23	28	24.9	19.5	62.6
E.F. Salmon River	1987	4/8	-	5	-	Not enough recaptures at the Snake R. trap.		
	1986	4/8	5/24	9	45	14.6	24.7	73.9
	1985	4/17	5/1	22	22	30.0	20.6	56.4
Hells Canyon	1988	4/24	5/7	38	14	12.3	-	31.0
	1987	3/26	5/19	16	55	3.1	-	33.5
	1986	4/29	5/1	38	2	86.4	-	69.1
	1985	4/30	5/3	44	3	57.6	-	52.9
Spring Cr.	1988	4/17	4/25	28	9	26.9	-	34.5
		4/17	4/23	28	7	34.6	-	35.7
		4/17	4/25	30	9	26.9	-	34.5
		4/17	4/23	14	7	34.6	-	35.7
		4/18	4/25	38	8	30.3	-	35.0
		4/18	4/24	21	7	34.6	-	35.7
	1987	4/26	-	-	-	Not enough recaptures at the Snake R. trap.		
	1986	5/1	5/27	14	26	9.3	-	72.9
		4/30	-	1	-	Not enough recaptures at the Snake R. trap.		
		4/3	-	2	-	Not enough recaptures at the Snake R. trap.		
	1985	5/9	5/19	36	10	24.2	-	46.4
		5/9	5/20	31	11	22.0		47.0
Cottonwood Cr.	1987	4/26	4/30	28	5	18.6	-	39.3
	1986	4/28	5/5	39	7	13.0	-	72.3
		4/28	5/5	30	7	13.0	-	72.3
		4/28	5/5	42	7	13.0	-	72.3
Little Sheep Cr.	1987	5/2	-	-	-	Not enough recaptures at the Snake R. trap.		
	1986	4/28	5/8	16	10	12.0	-	72.1
		4/27	-	2	-	Not enough recaptures at the Snake R. trap.		
Wildcat Cr.	1988	4/23	4/26	86	4	33.2	-	32.7
		4/23	4/26	66	4	33.2	-	32.7

Release Site to the Clearwater Trap

Chinook salmon. Six groups of freeze branded chinook salmon were released from Dworshak NFH on March 30, 1988. The travel time for these groups was one day (Table 10). This compares to a travel time of four days in 1987 and one day for 1986 and 1985. Average discharge during the migration period in 1987 was 7,200 cfs, 76% less than in 1986 (29,000 cfs) and 58% less than in 1985 (17,300 cfs). Discharge in 1988 was 9,600 cfs, 14% higher than in 1987. The extreme low discharge in 1987 is most likely responsible for the 75% reduction in travel time.

One group of 0-age chinook was released from Dworshak NFH on March 30. This group moved slower (travel time = 2 days) than the normal hatchery production (travel time = 1 day).

A group of 0-age chinook was released from Dworshak NFH on September 28, 1987. This groups median passage at the Clearwater River trap was March 27. The first chinook from this group arrived at the trap on March 17, and marks continued to be captured for the next two weeks.

The Red River group began arriving on March 29 and the last recapture was on June 6 with the median passage on April 15.

Steelhead trout. There were four groups of freeze branded steelhead released from Dworshak April 3 and 4. The median travel time for all four groups was one day, producing a migration rate of 55.0 km/day. In previous years the travel time for the Dworshak brand groups was one day (Table 11).

Head of Lower Granite Reservoir to Lower Granite Dam

Chinook salmon freeze brand groups. In 1988, only eight of the 28 groups of freeze branded yearling chinook salmon could be used for travel time calculations through Lower Granite Reservoir because of the operational problems at the Snake River trap discussed earlier. All usable groups were from the Clearwater River drainage. There were also three groups of 0-age spring chinook; two released from the Lookingglass Hatchery and one from Dworshak NFH. Average travel time through lower Granite Pool for the Clearwater River yearling chinook salmon freeze brand group ranged from 21 days for the groups released the last of March, to 35 days for the group released in mid March (Table 11). Average travel time for the 0-age chinook ranged from 28 for the two groups released in mid May, to 57 days for the group released from Dworshak NFH on April 1.

A linear regression analysis of migration rate through Lower Granite Pool and discharge was run on the eight freeze brand groups released in the spring. In an attempt to linearize the relationship, both variables were log transformed. We found that the linear regression of log migration rate and the

Table 10. Migration statistics for branded chinook salmon and steelhead trout released above the Clearwater River trap, 1987 and 1988.

Release Site	Year	Sp.	Median Release	Median Passage	Number Captured	Migration Rate Km/day	Travel Time	Mean Discharge
Crooked River	1987	St	04/14	-	2	-	-	-
Dworshak NFH	1987	St	04/21	04/22	58	-	-	-
		St	05/05	-	-	-	-	-
		Ch	04/01	04/04	1416	13.8	4	7.2
Clear Creek		St	04/17	04/20	59	28.8	4	14.1
Dworshak NFH	1988	St	05/03	05/04	107	55.0	1	16.9
		St	05/03	05/04	95	55.0	1	16.9
		St	05/03	05/04	81	55.0	1	16.9
		St	05/04	05/05	202	55.0	1	16.9
		Ch	03/30	04/01	239	27.5	2	9.8
		Ch	03/30	03/31	1711	55.0	1	9.6
		Ch	03/30	03/31	788	55.0	1	9.6
		Ch	03/30	03/31	571	55.0	1	9.6
		Ch	03/30	03/31	253	55.0	1	9.6
		Ch	03/30	03/31	181	55.0	1	9.6
		Ch	09/28/87	03/27	16	-	182	-
Red River		Ch	09/30/87	04/14	18	-	198	-

Table 11. Chinook salmon smolt travel time and migration rate to Lower Granite Dam from the head of Lower Granite pool using fish passing the Snake River trap from upriver releases, 1985 through 1988.

			Snake River/ Clearwater River trap		Lower Granite Dam				
Year	Brand	Release site	Median passage date	Number collected	Median arrival date	Number collected	Travel time (days)	Migration rate (km/day)	Mean Q(kcfs) at LGD
1985	LDR-3	Hells Canyon	4/3	544	4/13	7,111	10	5.2	88
	RDR-1	Sawtooth Hat.	4/14	165	5/4	4,313	20	2.6	89
	RDR-3	S. F. Salmon River	4/17	76	5/14	4,193	27	1.9	85
	LDR-1	Rapid River	4/12	370	4/25	9,422	13	4.0	98
	LDR-4	Grande Ronde River	6/4	135	6/23	6,868	19	2.7	79
	RDR-2	Dworshak NFH	4/4	248	4/27	6,403	23	2.7	94
1986	LDY-3	Hells Canyon	4/3	269	4/16	9,898	13	4.0	100
	RDY-1	Sawtooth Hat.	4/14	49	4/23	2,245	9	5.7	89
	RDY-3	S. F. Salmon River	4/23	229	5/3	5,921	10	5.2	98
	LDY-1	Rapid River	4/16	237	4/20	10,589	4	12.9	88
	RAJ-2	Lookingglass Cr.	4/5	38	4/14	3,741	9	5.7	99
	RAJ-3	Lookingglass Cr. 3/	4/4	13	4/9	333	5	10.3	99
	RAJ-4	Lookingglass Cr.	4/5	76	4/21	2,593	16	3.2	95
	RAY-1	Dworshak NFH	4/2	312	4/21	4,703	19	3.2	97
1987	RAR-1	Dworshak NFH	4/4	1,416	4/24	11,069	20	3.1	37
	RD4-1	Clearwater River 1/	3/20	43	4/18	551	29	2.1	33
	RD4-3	Clearwater River 1/	4/2	50	4/20	436	18	3.4	35
	RA4-3	Clearwater River 1/	4/7	165	4/19	438	12	5.1	38
	RA4-1	Clearwater River 1/	4/13	74	4/29	334	16	3.8	46
1988	LAUO-1	Lookingglass Hat. 2/	5/15	29	6/11	3,913	27	1.9	68
	LAUT-1	Lookingglass Hat. 2/	5/16	25	6/12	3,973	27	1.9	68
	RDT-3	Red River Pond 3/	4/15	18	5/13	1,071	28	2.2	58
	LAH-1	Dworshak NFH 2/	4/1	239	5/27	3,457	56	1.1	54
	LAT-2	Dworshak NFH	3/31	1,711	4/20	17,510	20	3.1	38
	LDT-1	Dworshak NFH 3/	3/28	16	4/12	847	15	4.1	30
	RA7N-1	Dworshak NFH	3/31	788	4/20	6,672	20	3.1	38
	RA7N-3	Dworshak NFH	3/31	571	4/21	5,823	21	2.9	39
	RAR-1	Dworshak NFH	3/31	253	4/20	2,040	20	3.1	38
	RAR-3	Dworshak NFH	3/31	181	4/21	1,852	21	2.9	39
	LDK-1	Clearwater R. Trap 1/	3/15	51	4/19	736	35	1.8	32
	LDK-3	Clearwater R. Trap 1/	3/18	93	4/19	643	32	1.9	33
	RDK-1	Clearwater R. Trap 1/	4/2	27	4/23	499	21	2.9	42
	RDK-2	Clearwater R. Trap 1/	4/7	18	4/22	347	15	4.1	45
	RDK-3	Clearwater R. Trap 1/	3/22	83	4/19	575	28	2.2	34
	RDK-4	Clearwater R. Trap 1/	4/14	31	4/30	524	16	3.8	53

1/ Releases made on Clearwater River at U.S. Highway 95 launch (Rkm-15.5).
2/ 0-Age spring chinook salmon.
3/ Fall release of spring chinook.

log of discharge provided the best fit ($N=8$, $r^2=0.950$, $P=0.000$):

log migration rate = -8.717 + 2.677 log discharge.

This indicates that as discharge increased, travel time through the reservoir decreased (migration rate increases).

<u>Chinook salmon PIT tag groups.</u> In 1988, sufficient numbers of chinook salmon were PIT tagged daily at the Snake River trap to provide 23 daily release groups (3,767 total) for estimating travel time and migration rates through Lower Granite Reservoir. Median travel time ranged from 23 days early in the migration season to six days late in the season (Table 12). There was a substantial change in median travel time between April 8 and April 18. Prior to April 8, the average median travel time through Lower Granite pool was 19.7 days (migration rate = 2.6 km/day), and after April 18 the average median travel time was 8.6 days (migration rate = 6.0 km/day). Average daily discharge for the PIT tag groups released prior to April 8 was 40.3 kcfs and ranged from 31 to 48 kcfs. Average daily discharge for PIT tag groups released after April 18 was 56.9 kcfs and ranged from 49 to 69 kcfs.

A linear regression of travel time and discharge was calculated and showed a strong relationship between the two variables. The linear regression of the log of migration rate and log discharge provided the best fit ($N=23$, $r^2=0.840$, $p=0.000$):

log migration rate = -5.209 + 1.715 log average discharge.

This analysis indicates that chinook salmon travel time in Lower Granite Pool decreases as discharge increases.

An analysis of covariance of travel time through Lower Granite Reservoir for freeze branded and PIT tagged chinook salmon showed no statistical difference at the 0.5 level. PIT tagged and freeze branded chinook salmon migrated at about the same rate through the reservoir (Fig 9).

Percent recovery (integration) of daily release PIT tagged chinook groups at Lower Granite Dam ranged between 25.8% and 45.7%, and averaged 32.9%. Seasonal cumulative percent recovery of pit tagged chinook salmon to Lower Granite was 32.8%, to Little Goose it was 47.3%, and to McNary it was 55.2%. These numbers are cumulative percents as you progress downstream.

<u>Hatchery steelhead trout freeze brand groups.</u> In 1988 median passage dates were calculated for 11 groups of freeze branded steelhead trout at the Snake River trap and seven groups at the Clearwater River trap. These groups were used to determine migration rate and travel time through Lower Granite Reservoir (Table 13). The five groups released in Spring Creek, that were used in the travel time calculations, were the slowest moving groups in Lower Granite pool with travel times ranging from 13 to 23 days (average = 18 days). The next slowest groups were the Wildcat Creek groups (16 days). The Clearwater River brand groups and the Hells Canyon brand group moved through the reservoir at the fastest rate, ranging from six to nine days and averaged eight days.

Table 12. Chinook salmon PIT tag travel time, with 95% confidence interval, from the head of Lower Granite Pool to Lower Granite Dam, 1988.

Release date	Median travel time (day)	Confidence Interval* Upper	Lower	Number captured	Percent captured	Average discharge (kcfs)
03/25/88	22.2	24	20	72	35.8	30.73
03/26/88	23.6	25	22	66	33.0	34.85
03/28/88	23.0	25	22	69	34.5	36.96
03/29/88	21.6	25	21	70	35.0	37.27
03/30/88	20.4	23	18	71	35.5	36.13
03/31/88	20.8	22	19	53	26.4	39.45
04/01/88	19.3	21	18	65	32.0	38.67
04/02/88	21.9	27	20	54	26.9	43.65
04/04/88	15.6	18	15	61	30.3	40.83
04/05/88	16.5	19	15	64	30.8	43.84
04/06/88	18.7	24	16	61	30.5	46.94
04/07/88	18.5	26	16	42	27.3	47.87
04/08/88	14.1	16	12	33	27.3	46.68
04/18/88	11.4	13	10	76	40.4	56.67
04/19/88	11.0	14	10	69	34.5	54.44
04/20/88	9.5	11	9	51	34.2	54.26
04/21/88	9.7	13	8	48	32.0	51.28
04/22/88	10.4	13	8	62	41.1	49.87
04/25/88	11.1	12	10	49	34.8	49.24
04/26/88	10.5	17	8	16	30.2	49.23
05/15/88	8.3	18	5	36	32.7	67.79
05/16/88	6.3	13	4	32	45.7	68.70
05/17/88	7.2	12	4	17	25.8	67.46

*confidence intervals calculated with nonparametric statistics

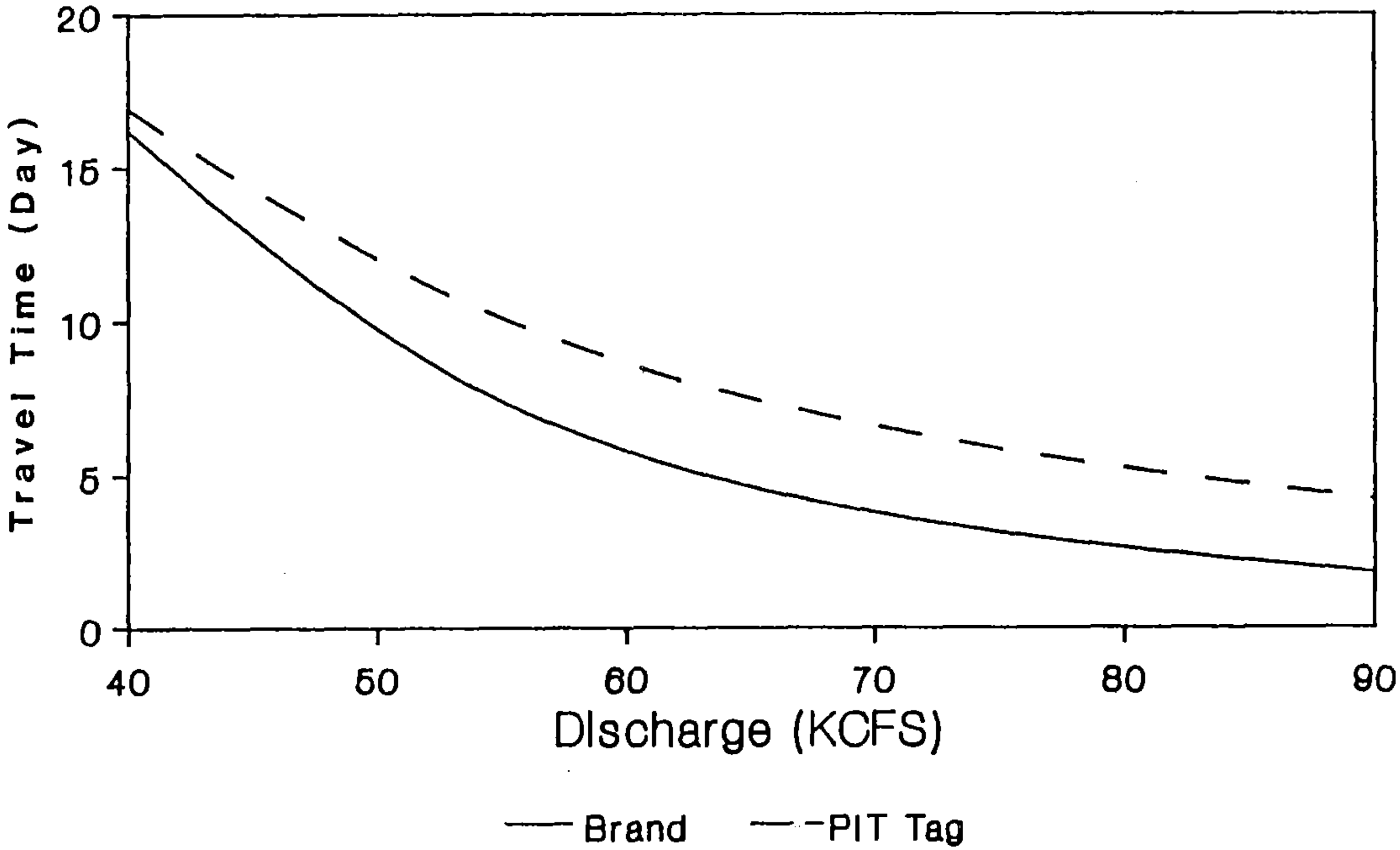


Figure 9. Relationship between travel time through Lower Granite Reservoir and discharge for freeze branded and PIT tagged chinook, 1988.

Table 13. Steelhead trout smolt travel time and migration rate to Lower Granite Dam from the head of Lower Granite pool using fish passing the Snake River trap from upriver releases, 1985 through 1988.

			Snake River/ Clearwater River trap		Lower Granite Dam				
Year	Brand	Release site	Median passage date	Number collected	Median arrival date	Number collected	Travel time (days)	Migration rate (km/day)	Mean Q(kcfs) at LGD
1985	LDY-1	Hells Canyon	5/3	44	5/11	2,821	8	6.5	88
	RDY-1	Sawtooth Hatchery	5/7	23	5/28	3,510	21	2.5	92
	RDY-3	E. F. Salmon River	5/9	22	5/28	2,454	19	2.7	93
	RA17-1	Grande Ronde River	5/20	36	5/22	12,710	2	25.8	102
	RA17-3	Grande Ronde River	5/19	31	5/21	12,022	2	25.8	95
	LDY-2	Dworshak NFH	4/29	88	5/4	6,699	5	12.3	83
1986	RDT-2	Hells Canyon	5/1	38	5/8	5,033	7	7.4	94
	LDT-2	Sawtooth Hatchery	5/21	11	5/29	3,772	8	6.5	120
	LDT-4	E. F. Salmon River	5/23	9	5/29	1,552	6	8.6	119
	RAJ-4	Little Sheep Cr.	5/8	16	5/30	1,340	22	2.3	114
	RAJ-1	Spring Creek	5/27	14	5/26	1,628	Median arrival date at LGD one day before median passage date at Snake R. trap.		
	RAIJ-1	Cottonwood Cr.	5/5	39	5/21	4,468	16	3.2	98
	RAIJ-3	Cottonwood Cr.	5/5	43	5/22	5,151	17	3.0	100
	RAIJ-4	Cottonwood Cr.	5/6	29	5/18	4,114	12	4.3	99
	RDT-4	Dworshak NFH	5/8	18	5/17	7,194	9	6.8	99
	LD4-1	Clearwater R. Trap 1/	5/8	2	5/14	1,003	6	10.3	100
	LD4-3	Clearwater R. Trap 1/	5/13	5	5/22	869	9	6.8	98
	RD4-1	Clearwater R. Trap 1/	4/16	7	4/23	371	7	8.8	103
	RD4-3	Clearwater R. Trap 1/	5/1	1	5/8	751	7	8.8	94
1987	RAIC-1	Cottonwood Cr.	4/30	7	5/4	4,886	4	12.9	86
	RAIC-2	Cottonwood Cr.	4/30	6	5/4	5,529	4	12.9	86
	RAIC-3	Cottonwood Cr.	4/30	7	5/4	5,971	4	12.9	86
	RAIC-4	Cottonwood Cr.	4/30	8	5/5	4,936	5	10.3	84
	RAR-3	Clear Cr.	4/20	59	5/1	3,500	11	4.7	59
	RDR-3	Dworshak NFH	4/22	58	5/1	4,917	9	6.8	63
	RDK-1	Clearwater R. Trap 1/	4/13	6	4/26	1,192	13	4.7	41
	RDK-2	Clearwater R. Trap 1/	4/20	9	4/30	999	10	6.2	56
	RDK-4	Clearwater R. Trap 1/	4/28	2	5/4	692	6	10.3	84
1988	LDT-3	Hells Canyon	5/7	38	5/15	6,631	8	6.5	69
	LDT-2	Sawtooth Hatchery	5/7	19	5/25	5,332	18	2.9	68
	LAIF-1	Spring Creek	4/25	30	5/17	4,912	22	2.3	59
	LAIF-3	Spring Creek	4/24	28	5/7	3,865	13	4.0	54
	RAIF-3	Spring Creek	4/24	38	5/7	6,502	13	4.0	53
	LAIM-1	Spring Creek	4/25	29	5/17	3,799	22	2.3	59
	LAIM-3	Spring Creek	4/23	14	5/16	4,030	23	2.2	59
	RAIM-3	Spring Creek	4/24	23	5/11	5,060	17	3.0	58
	RAIF-1	Wildcat Creek	4/26	88	5/10	14,820	14	3.7	58
	RAIM-1	Wildcat Creek	4/26	67	5/11	13,749	15	3.4	58
	LD4-3	Snake River @ Asotin	5/24	30	5/30	854	6	8.6	76
	RD4-1	Snake River @ Asotin	5/24	55	5/30	994	6	8.6	76

Table 13. (continued)

Year	Brand	Release site	Snake River/ Clearwater River trap: Median passage date	Snake River/ Clearwater River trap: Number collected	Lower Granite Dam: Median arrival date	Lower Granite Dam: Number collected	Travel time (days)	Migration rate (km/day)	Mean Q(kcfs) at LGD
1988	RAT-1	Dworshak NFH	5/3	107	5/11	10,792	8	7.7	72
	RAT-2	Dworshak NFH	5/3	95	5/11	7,225	8	7.7	72
	RAT-3	Dworshak NFH	5/3	81	5/9	5,928	6	10.3	73
	RAT-4	Dworshak NFH	5/3	202	5/10	25,335	7	8.8	78
	RA4-1	Clearwater R. Trap 1/	4/14	28	4/22	1,335	8	7.7	57
	RA4-3	Clearwater R. Trap 1/	4/23	8	5/1	1,384	8	7.7	49
	RD4-3	Clearwater R. Trap 1/	4/29	16	5/6	743	7	8.8	50

1/ Releases made on Clearwater River at U.S. Highway 95 launch (Rkm-15.5).

The relationship between hatchery steelhead migration rate through Lower Granite pool and discharge was analyzed using a linear regression model. The best fitting equation (N=17, r^2=0.343, P=0.013) was:

log migration rate = -5.446 + 1.698 log average discharge.

This equation indicates that as discharge increases migration rate increases. When this data is compared to 1987 data, hatchery steelhead rate of movement through the reservoir was about the same for both years.

Hatchery steelhead trout PIT tag groups. In 1988 sufficient numbers of hatchery steelhead trout were PIT tagged daily at the Snake River trap providing 29 daily release groups (1,743 individual fish) to be used in median migration rate calculations through Lower Granite Pool. Median travel time ranged from 10.4 to 3.5 days (5.0 km/day to 14.7 km/day), and averaged 5.6 days (Table 14). A linear regression analysis between migration rate in Lower Granite Pool and average Lower Granite discharge per PIT tag group was conducted. The best linear regression equation (N=29, r^2=0.366, P=0.001) was:

log median migration rate = -2.133 + 1.053 log discharge.

The fact that only 37 of the variation in median travel time is accounted for by change in discharge may be due to the low numbers of data points at discharges other than 60,000 and 70,000 cfs.

To remove some of the noise which is often associated with biological data and better show the underlying biological relationship, migration rate was calculated by 5 kcfs discharge groups (Mosteller and Tukey 1977:75). A linear regression analysis was conducted and found that the best linear regression equation (N=8, r^2=0.905, P=0.000) was:

log migration rate = -1.904 + 1.010 log mean discharge.

The high coefficient of determination (r^2) indicates a strong relationship between hatchery steelhead trout migration rate through Lower Granite Reservoir and mean discharge. The low probability (P) indicates this relationship is highly significant. The equation shows that as discharge increases migration rate increases.

Percent recovery of daily hatchery steelhead PIT tag release groups at Lower Granite Dam ranged from 18.3% to 81.7% and averaged 61.3%. Overall seasonal cumulative recovery of PIT tagged hatchery steelhead to Lower Granite was 61.3%, to Little Goose it was 72.2%, and to McNary it was 72.9%. This was considerable higher than in 1987 when the seasonal recovery at Lower Granite was only 39.2%, and most likely reflects an increased FGE from raised operating gates at the project.

Wild steelhead trout PIT tag groups. In 1988 sufficient numbers of wild steelhead trout were PIT tagged at the Snake River trap to provide 24 daily release PIT tag groups (1186 individual fish) for median travel time calculations (Table 15). Only since the introduction of the PIT tag have

Table 14. Hatchery steelhead trout PIT tag travel time, with 95% confidence interval, from the head of Lower Granite pool to Lower Granite Dam, 1988.

Release date	Median travel time (day)	Confidence Interval* Upper	Lower	Number captured	Percent captured (%)	Average discharge (kcfs)
04/18/88	4.8	6	4	40	65.6	65.04
04/19/88	5.0	7	4	48	80.0	64.22
04/20/88	4.7	9	4	34	56.7	60.98
04/21/88	6.0	8	5	44	73.3	56.48
04/22/88	6.4	8	6	38	62.3	53.62
04/25/88	10.4	1	2	94	68.3	46.09
04/26/88	9.7	11	8	37	61.7	49.23
04/28/88	7.6	9	6	27	52.9	49.88
04/29/88	6.0	7	5	36	60.0	46.25
05/02/88	5.8	8	5	41	68.3	64.88
05/03/88	3.7	5	3	39	65.0	65.45
05/04/88	4.6	6	3	37	61.7	77.54
05/05/88	4.0	5	3	49	81.7	82.45
05/06/88	4.3	6	4	45	73.8	82.10
05/09/88	5.3	6	4	37	61.7	64.68
05/10/88	4.5	5	4	35	56.5	63.88
05/11/88	4.0	6	4	39	65.0	62.03
05/12/88	3.5	4	3	40	67.8	67.80
05/13/88	3.7	6	3	40	66.7	70.38
05/14/88	8.1	11	6	38	63.3	69.76
05/15/88	5.3	7	5	42	68.9	72.46
05/16/88	6.5	10	4	31	51.7	67.39
05/17/88	6.3	7	5	42	66.7	67.43
05/18/88	6.5	7	5	36	60.0	66.08
05/23/88	3.7	10	3	34	56.7	76.62
05/24/88	4.8	7	4	34	55.7	78.04
05/25/88	5.5	8	5	25	42.4	75.98
05/26/88	6.4	7	5	27	44.3	72.83
06/07/88	5.3	9	5	11	18.3	60.90

* Confidence intervals calculated with nonparametric statistics

Table 15. Wild steelhead trout PIT tag travel time, with 95% confidence intervals, from the head of Lower Granite pool to Lower Granite Dam, 1988.

Release date	Median travel time (day)	Confidence Interval* Upper	Lower	Number captured	Percent captured (%)	Average discharge (kcfs)
04/18/88	3.5	4	3	29	49.2	65.23
04/19/88	3.5	4	3	31	50.0	64.70
04/20/88	4.0	4	3	33	54.1	63.10
04/21/88	4.5	6	4	36	60.0	59.97
04/22/88	4.6	6	4	32	53.3	55.62
04/25/88	6.6	9	5	25	52.1	45.66
04/26/88	6.1	7	5	25	64.1	45.05
05/02/88	3.8	5	3	32	68.1	55.50
05/03/88	3.5	4	3	21	48.8	59.57
05/04/88	3.2	4	3	22	51.2	73.90
05/05/88	3.4	4	2	29	60.4	82.67
05/06/88	3.7	4	3	27	62.8	82.10
05/09/88	4.3	6	3	16	47.1	63.72
05/10/88	3.6	4	3	36	70.6	61.02
05/11/88	3.4	5	3	30	58.8	57.60
05/12/88	2.7	3	2	35	60.3	66.87
05/13/88	2.9	3	3	38	63.3	71.47
05/14/88	3.8	5	3	37	61.7	72.17
05/15/88	3.7	5	3	34	55.7	72.80
05/16/88	3.5	4	3	42	70.0	73.53
05/17/88	3.3	3	3	43	70.5	74.87
05/24/88	3.7	4	3	19	63.3	79.05
05/25/88	4.7	8	3	13	65.0	77.00
05/26/88	4.0	13	2	10	55.6	76.10

* Confidence intervals calculated with nonparametric statistics

sufficient numbers of wild steelhead trout been marked to provide travel time data through Lower Granite Reservoir. The PIT tag is the only tool available that can provide this type of data because of the low numbers of fish required for marking due to the high recovery rate at Lower Granite Dam. Median travel time for wild steelhead trout ranged from 6.6 days (7.8 km/day) to 2.7 days (19.1 km/day), and averaged 3.9 days (13.7 km/day). There is a significant difference in median travel time between hatchery and wild steelhead trout. The slopes of the two lines, migration rate/discharge for hatchery and wild steelhead trout, were tested with the analysis of covariance and found to not be significantly different at the 0.5 level. Then the height of the two lines were tested and there was a significant difference in the migration rate of hatchery vs. wild steelhead trout. It is uncertain as to the reason for this difference. A possible explanation is that wild steelhead may be stronger and/or more fully smolted and therefore travel faster as they migrated through Lower Granite Reservoir.

A linear regression analysis between median migration rate in Lower Granite Reservoir and mean discharge for each PIT tag group was conducted. The best linear regression equation ($N=24$, $r^2=0.381$, $P=0.001$) was:

$$\log \text{migration rate} = -0.576 + 0.758 \log \text{mean discharge}.$$

This analysis shows that as discharge increases, travel time in Lower Granite Reservoir decreases.

A linear regression analysis was conducted on average travel time separated into 5 kcfs groups. The analysis showed that the equation:

$$\log \text{migration rate} = -1.020 + 0.868 \log \text{average discharge}$$

had the best fit ($N=7$, $r^2=0.526$, $P=0.065$).

An analysis of the slope of the migration rate/discharge relationship for freeze brand data, the hatchery steelhead trout PIT tag data, the wild steelhead trout PIT tag data, the hatchery steelhead trout PIT tag data averaged by 5 kcfs groups, and the wild steelhead trout PIT tag data averaged by 5 kcfs groups was conducted to see if there was a significant difference between the five groups of data (Fig. 10). The analysis of variance showed there was not a significant difference between the slopes at the 0.05 level, but the relationship was significant at the 0.1 level ($N=87$, $F=2.196$, $P=0.077$). When a graphic representation of the slopes of the five sets of data was examined, it was obvious the freeze brand data was significantly different from the other four sets of data. When the freeze brand data was removed from the analysis there no longer was a significant difference between the slopes of the other four sets of data ($N=68$, $F=1.076$, $P=0.336$). The difference between the freeze brand data and the PIT tag data is probably an artifact of the technique used to estimate migration rate rather than a real difference in migration rate between the two mark methods.

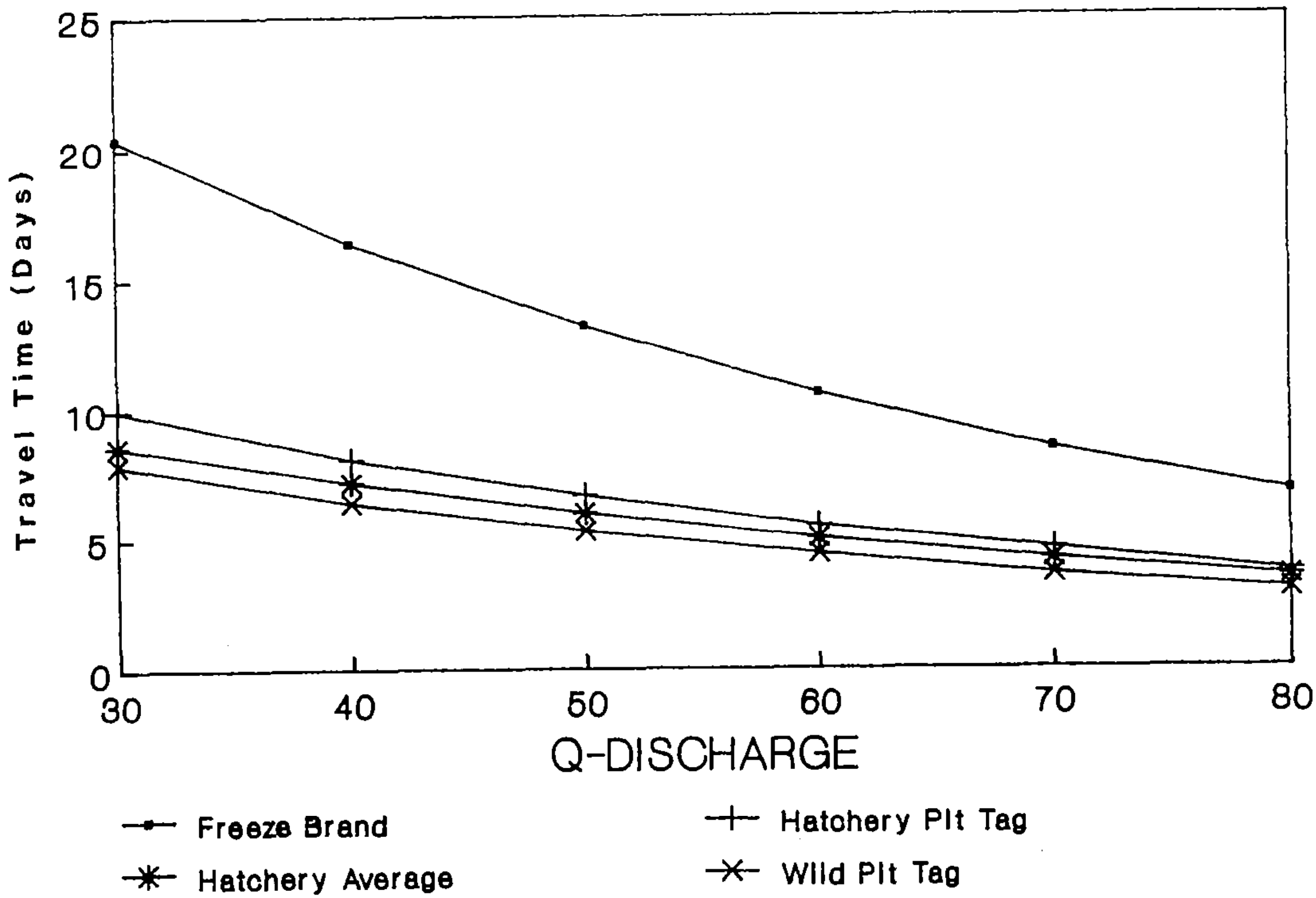


Figure 10. Relationship between travel time through Lower Granite Reservoir and discharge for freeze branded steelhead (FB), PIT tagged hatchery and wild steelhead (SH and SW), and PIT tagged hatchery and wild steelhead averaged by 5 kcfs groups (SH by 5 kcfs and SW by 5 kcfs), 1988.

The height of the lines was tested and found there was a significant difference between the hatchery and wild steelhead migration rate/discharge relationship. Wild steelhead trout estimated migration rate through Lower Granite Reservoir at 45,000 cfs is 9.8 km/day, while hatchery stelhead is 7.0 km/day. At 85,000 cfs, wild steelhead estimated migration rate is 17.1 km/day, and hatchery steelhead estimated migration rate is 13.2 km/day. Wild steelhead trout migrate through Lower Granite Reservoir faster than hatchery steelhead trout.

The PIT tag data provides the ability to get a travel time to average discharge relationship over a broader range of flows and time than the freeze brand data because of the ability to release more marked groups. This makes the PIT tag a much more valuable tool for estimating travel time through Lower Granite Pool than freeze brands.

Percent recovery of daily wild steelhead trout PIT tag release groups at Lower Granite Dam ranged from 47.1% to 70.6% and averaged 59.0%. Overall seasonal cumulative recovery of PIT tagged wild steelhead trout to Lower Granite Dam was 58.9%, to Little Goose it was 72.8%, and to McNary it was 74.5%. The percent recovery at the three dams for PIT tagged hatchery and wild steelhead was about the same in 1988.

SUMMARY

Hatchery production of chinook salmon and steelhead trout for release above Lower Granite Dam in 1988 was 21,974,463 (11,176,084 chinook salmon and 10,798,379 steelhead trout). Of these, 722,553 chinook salmon and 549,170 steelhead trout (6.5% and 5.1% of the total release, respectively) were freeze branded and released in 28 unique groups for chinook salmon and 23 unique groups for steelhead trout. The number of freeze branded chinook salmon and steelhead trout was up 162% and 112%, respectively, in 1988.

The Snake River trap was operated from March 5 through June 29. The trap was moved to the east side of the Snake River on April 27 where it was believed the trap would be more efficient at collecting smolts during a low water year. The Snake River trap captured 3,758 yearling chinook, 2,604 wild steelhead trout, and 16,772 hatchery steelhead trout. Most of the chinook salmon smolts had already passed the trap by the time the trap was moved to the east side of the river so the chinook catch was only slightly better than in 1987. The steelhead trout (wild and hatchery) trap catch was better than in any previous year and nearly 200% better than 1987's low water conditions.

The Clearwater River trap was operated from March 8 through June 12 with a 15 day period in mid-May when the trap was out of operation due to high discharge. Clearwater River trap catch was 63,983 chinook salmon, 458 wild steelhead trout and 9,940 hatchery steelhead trout. In 1988 trap catch of

chinook salmon was down 12% from 1987 but the percent of hatchery chinook released in 1988 was down 28%. The increase in percent chinook trap catch in 1988 can be attributed to either improvements in the trap livewell velocity barrier and/or an increase in wild escapement.

The Clearwater River trap catch of hatchery steelhead trout was up 79% in 1988. The number of hatchery steelhead trout released was up 29% from 1987, but the ratio of hatchery steelhead trout caught in the trap compared to the number of hatchery steelhead trout released was up 39%. This 10% difference may be attributed to natural variation and/or to the trap modification mentioned above. Trap catch of wild steelhead trout was down 49% in 1988 from 1987.

No trap efficiency tests were conducted on the Snake River trap for chinook salmon in 1988 due to the low trap catch. A best guess estimate of trap efficiency for 1988 would be similar to that experienced in 1987 which was 10 to 30 times less than the 1.2% trap efficiency of previous years. Trap efficiency tests on the Clearwater River trap in 1988 were combined with four previous years data, for a total of 36 tests, the resulting efficiency value was 2.69%, with a 95% confidence interval of 0.08%. The 1988 data by itself yielded an efficiency value of 2.80%, with a 95% confidence interval of 0.09%.

River discharge values were combined with the trap efficiency data for both the Snake and Clearwater river traps in an attempt to create a predictive equation. The only set of data that showed a significant relationship between trap efficiency and river discharge was the Clearwater River trap chinook data. A significant statistical interaction was shown at the 0.05 level with $P=0.019$ and $F=6.103$, but further analysis showed an R^2 of 0.152, indicating no practical or biological significance. This anomaly indicates the possibility that some other variable also has an influence on trap efficiency in addition to river discharge.

Trap efficiencies for steelhead trout at the Snake River trap, using trap caught fish (three test groups) to provide the best estimate, for 1988 averaged 0.30%. Steelhead trout trap efficiencies at the Clearwater River trap in 1988 were tested only twice and yielded an average of 0.44%. The steelhead trout efficiency estimates at both the Snake and Clearwater river traps were made with the 1988 tests only because the data for all years failed to meet the statistical criteria for pooling.

Migration rate from point of release to the Snake River trap was not calculated for spring chinook because of the low chinook trap catch. Migration rates for branded steelhead trout to the Snake River trap was better in 1988 than in 1987 because flows during the major steelhead migration period were more conducive to migration in 1988.

Migration rate for Clearwater River branded chinook salmon was faster than in 1987 and similar to 1986 and 1985. Flows were 2,000 to 4,000 cfs higher for a major portion of the migration in 1988 as compared to 1987. Steelhead migration rate was the same as in previous years.

Migration rate (travel time) through Lower Granite Reservoir for Clearwater River freeze branded chinook salmon was similar to 1987, but considerably lower than the normal flow year of 1986. No data is available for chinook salmon migrating from the Snake River above the Clearwater River through Lower Granite Reservoir.

PIT tagged chinook salmon migrated at the same rate as the freeze branded smolts. Prior to April 8, when discharge was below 40 kcfs, PIT tagged chinook salmon travel time through the reservoir averaged 19.7 days. After April 18, when discharged averaged 57 kcfs, travel time through the reservoir averaged 8.6 days. Statistical analysis showed a strong relationship between travel time and discharge, as discharge increases travel time for chinook salmon through the reservoir decreases dramatically. PIT tagged chinook salmon moved more than three times as fast through the reservoir at 80 kcfs as they did at 40 kcfs.

There was a statistical significant difference, at the 0.1 level, in travel time through Lower Granite Reservoir for freeze branded and PIT tagged steelhead trout. At low discharge, freeze branded steelhead trout move much slower than do PIT tagged steelhead trout. At higher discharges (100 kcfs) the difference is much less.

There is a very strong statistical relationship between travel time and discharge for PIT tagged hatchery steelhead trout. PIT tagged hatchery steelhead trout migrated twice as fast at 80 kcfs as they did at 40 kcfs.

Wild and hatchery PIT tagged steelhead trout migrate at about the same rate. The relationship between migration rate and discharge for wild steelhead trout is not as strong as for hatchery steelhead, but a good relationship still exists. PIT tagged wild steelhead trout migrate twice as fast through Lower Granite Reservoir, at 90 kcfs, as they did at 40 kcfs.

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